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JOURNAL OF THE INSTITUTE OF FOOD TECHNOLOGISTS

Symposium:

COLORIMETRY of FOODS

parts 1, 2, 3 & 4

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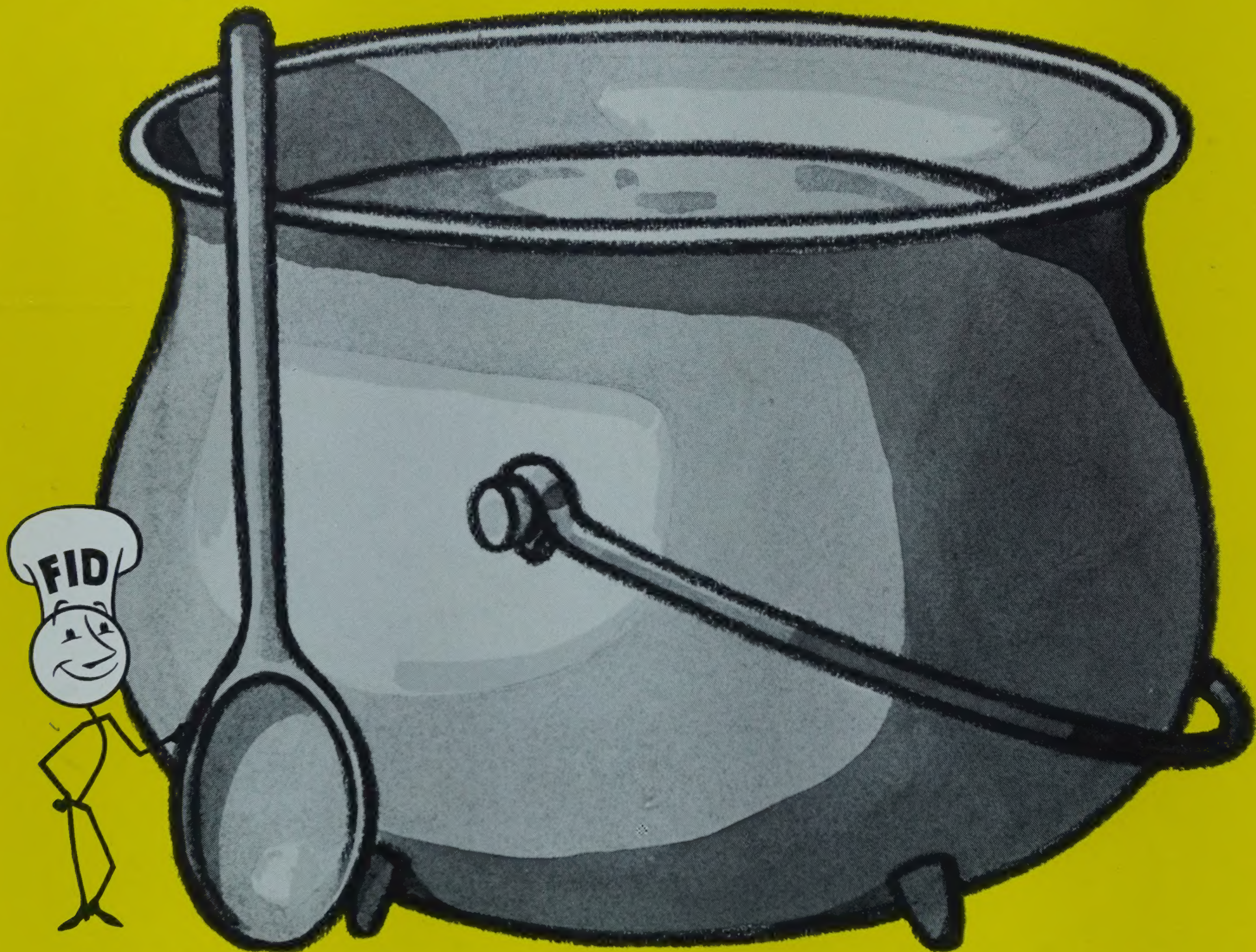

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food technology JAN. 1969

JOURNAL OF THE INSTITUTE OF FOOD TECHNOLOGISTS VOL. 23 NO. 1

COVER FOCUS

☐ **COLOR is the basic attribute of foods about which we know more than we do about its cousins, flavor and texture. Yet, more knowledge—and much more application of knowledge—is needed to help produce uniformly and safely colored food products. Here's some. . . . (spectrum on cover courtesy of Clemson University)**

RESEARCH:

GENERAL:

IFT AFFAIRS:

EDITOR'S POINT:

SCOPE IN BRIEF:

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FOOD TECHNOLOGY

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RESEARCH CONTENTS

PAGES 63–110——(Vol. 23, 63–110)

Research Manuscript Mailing Instructions:

Scientific Editor, Institute of Food Technologists, 221 N. LaSalle Street, Chicago, Illinois 60601—for research manuscripts and associated material only.

A STYLE GUIDE, "Research Papers for IFT Journals," is available upon request. The guide last appeared on page 165A of the 30 March 1967 issue.

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See complete Notice on page 70 (70).

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editor's point

The "Redcoats of '75"
—How Green a Valley for Tom?

☐ RECOGNITION and formulation of a problem often are the more creative steps compared to its solution. That's how Albert Einstein viewed the challenge of research.

This challenge takes on a new face, a new urgency, in the midst of an ongoing social revolution that shakes and involves the food world deeply. Our problems—the "Redcoats of 1975"—are already upon us and charging at us from out of the future at a furious pace: enough food for the hungry; pollution of water and air; waste in food production; inefficient labor; product nutrition defects; bugs in marketing and distribution; and on and on.

Tom is 15. Is he headed for the desolation of a modern Valley Forge? Can we stop the seemingly overwhelming force of the "Redcoats of 1975"? Can we get a revolution going against a dread taxation that will be forced upon him without any chance of representation? You can sense now that what must be done will take nothing short of a revolution in many ways, can't you?

☐ HERE ARE just a few concepts that could help to put some "Redcoats" to flight. You can easily extend the list by giving your imagination revolutionary reign.

• Air, air . . . Water, water . . . Shall life and life support materials be wrung from the earth's envelope through microbial conversion of N and C? Shall pollution control be viewed as a job for a public utility and not for the government inspector? In the still of night, could not giant fans draw strata of used air through pollutant adsorbing filters? And could not giant dams do a like job on rivers and lakes, with each upstream side perhaps made into one large activated sludge reservoir?

• Processing, engineering, distribution . . . Shall we have harvesting combines that process the harvest at nature's peak of perfection? Shall the power of the atom, the laser, and other new sources of energy find substantial application in food processing? Shall there be portable heat pumps for instant small-scale refrigeration or heating, portable condensers for the minute humidity in the air of arid regions? Shall we have thin-skinned pineapples? low-oxalate spinach? mycelium extenders that will make meat available to more people? Shall the process resistant, impermeable, completely destructible package step forward?

• Eye, nose & throat . . . Shall nature be made to deliver perfect color every time, through controlled cultivation, through blocking of pigment degradation? Shall we have a measure of control over nature's flavor-producing reactions? Shall our flavor experience be consistently heightened through physiologically active agents that adjust our receptivity to stimuli?

☐ TOMORROW'S food professionals must meet the challenges of an even more complex world, with more specialized needs. Prepare now to represent Tom **before** he has a vote. Revolutionize now the weapons you will pass on to him to keep his valley green and the "Redcoats" on the slopes. Discover the Minute Man in yourself. It's Time.

Karl O. Herz

Our Munch

More than 200 quality-conscious snack food producers, as well as thousands of canners, meat packers, bakers, butter and cheesemakers, confectioners and other food processors select their precisely screened salt from the 22 different types and sizes — including our 8 exclusive Alberger natural flake grades — that we make especially for the food industry. ☐ You might say that Diamond Crystal is the industry's *flavorite* salt. Happily, each year the list grows. May we add your name?

ft/SCOPE
IN THIS ISSUE

MEASUREMENT OF VOLATILES TRANSFERRED FROM PLASTIC PACKAGING FILMS TO FOODS. R. A. WILKS JR. & S. G. GILBERT. *Food Technology* **23,** 47–52 (1969)—A hot-jar method relying for analysis on gas chromatography of headspace gas is described. Toluene used as adhesive solvent in producing PVDC-coated cellophane-polypropylene laminate was the solvent tested for in storage of cheese slices and cottonseed oil held in contact with the laminate. The method easily detected toluene accumulation in cheese slices well before the panel, but was less effective in the case of cottonseed oil. Work toward use of the method for predicting flavor stability of foods packaged in plastic films is discussed.

OXYGEN PERMEABILITY OF FLEXIBLE FILM PACKAGES FOR FOODS. E. G. DAVIS & R. A. BURNS. *Food Technology* **23,** 92–96 (1969)—Two methods gave similar results on hermetically-sealed packages, but only the atmospheric-pressure method was suitable on packages made from films that are fragile or susceptible to leakage at the seals. Several types of heat sealer used to make fin-sealed packages showed no effect on package permeability. Oxygen permeability values determined on a range of films by a volume-increase test-cell method were compared with those estimated on packages fin-sealed from the same materials. Similar values were found with the majority of films, but with others the differences were significant.

THERMAL DESTRUCTION AND REGENERATION OF ENZYMES IN GREEN BEAN AND SPINACH PUREE. R. RESENDE, F. J. FRANCIS & C. R. STUMBO. *Food Technology* **23,** 63–66 (1969)—An accurate heat penetration and lethality calculation enabled process values to be calculated for total processing time as low as 1 to 2 sec. Assays for peroxidase showed a z value of 88 and 29 for green bean and spinach puree, respectively. Spinach chlorophyllase had a z value of 22. An Fo process value of 5.0 was sufficient to prevent regeneration of peroxidase in spinach at temperatures up to 290°F. With green beans at temperatures of 270 and 290°F, process values of 31 and 245, respectively, were required to prevent peroxidase regeneration. All samples of spinach or green beans which showed no peroxidase regeneration were also negative for catalase.

INFLUENCE OF VARIOUS ACIDITIES AND PASTEURIZING TEMPERATURES ON THE KEEPING QUALITY OF FRESH-PACK DILL PICKLES. R. J. MONROE, J. L. ETCHELLS, J. C. PACILIO, A. F. BORG, D. H. WALLACE, M. P. ROGERS, L. J. TURNEY & E. S. SCHOENE. *Food Technology* **23,** 71–77 (1969)—Fresh-pack dill pickles were prepared under a variety of conditions with respect to: pasteurizing temperatures, initial equilibrated acidities, heating rates, and tightness of pack, obtained by varying brine percentages. Physical, chemical and microbiological measurements were made on the brine and on the pickle stock. Spoilage was prevented by initial, equilibrated acidities of 0.60% acetic acid and internal-product temperatures above 160°F. Pasteurizing temperatures of 170°F to 200°F caused internal damage to the structure of the cucumbers. The faster heating rates induced softening of the pickles, while a low brine percentage (25%) resulted in failure to attain the desired internal-product temperature (165°F).

RELATIVE ACTIVITIES OF COMMERCIALLY-AVAILABLE ENZYMES IN THE HYDROLYSIS OF FISH PROTEIN. M. B. HALE. *Food Technology* **23,** 107–110 (1969)—The relative activities of more than 20 commercially-available proteolytic enzymes were measured for the digestion of a washed and freeze-dried fish protein substrate. Concentration of enzyme required to effect a standard degree of digestion in 24 hr was the inverse measure of activity. Total soluble and insoluble solids were measured and used to calculate the degree of digestion. In this way reproducible results, not possible from filtrate analysis alone, were obtained. Pronase was most active but pepsin, pancreatin and papain provide much more digestive activity per unit of cost. Some data on amino acid and α-amino nitrogen contents of the hydrolysates are presented.

THE MEASUREMENT OF COLOR. F. M. CLYDESDALE. *Food Technology* **23,** 16–22 (1969)—The measurement and specification of a color means the location of a point representing that particular color in a three dimensional color solid. The development of such solids and the type of instrumentation necessary to achieve the measurement of color are described. The use of color coordinate systems along with associated problems in achieving uniform chromaticity with mathematical systems is discussed and the reduction of coordinates to more workable single functions along with the problems involved in such reductions are examined.

THE SAMPLE AS A PROBLEM IN "COLOR MEASUREMENT" OF FOODS. A. C. LITTLE & G. MACKINNEY. *Food Technology* **23,** 25–28 (1969)—Objective measurement of color characteristics of foods involves development of an analytical procedure that yields information relating to visual color perception. The problem is not to manufacture a product that meets a colorimetric specification but to determine whether or not the product meets certain criteria of quality. Attention is focused on the problems generated by physical characteristics of the sample, from the simplest case of opaque light-scattering to complicated cases that involve interactions of transmittance, reflectance, specific absorption, and light-scattering.

MEASUREMENT OF COLOR AND TURBIDITY IN SOLUTIONS. W. O. BERNHARDT. *Food Technology* **23,** 30–31 (1969)—In sugar solutions, scattering of light by particles plus a low concentration of colorants make use of tristimulus colorimetry impractical. A scattering index and an absorption index can give a function of "color" as seen by the eye. A sphere photometer that can provide these indexes is described.

COLOR AND PIGMENT CONTENT IN FRUITS AND VEGETABLES. F. J. FRANCIS. *Food Technology* **23,** 32–36 (1969)—The tristimulus "a" and "L" values generally correlate better with total carotenoid content than do visual ratings. With sweet potato puree, the "a" value alone correlates well. With squash, "a" or "Rd" value correlates well for some varieties and poorly for others. With fresh cranberries, surface color in berry mixtures is not a good predictor of pigment content. Color of wines and cranberry juice can be measured easily with conventional transmission tristimulus colorimetry. Absorption ratios as a simple index of pigment content and color are applicable only to material with the same type of colorant.

AROMA CONCENTRATION FOR DEHYDRATED FOODS. J. L. BOMBEN, D. G. GUADAGNI & J. G. HARRIS. *Food Technology* **23,** 83–86 (1969)—A process for making aroma concentrates suitable for addition to dehydrated foods consists of vacuum stripping with a noncondensable gas and collecting the aroma in refrigerated traps at atmospheric pressure. Aroma was stripped and concentrated from orange, apple and tomato juices. Material balances of the aroma compounds in Delicious apples showed that most of the aroma in the feed appeared in the aroma concentrate and losses in the other streams were negligible. It was possible to directly condense the aroma on a dehydrated product such as orange powder.

DIFFERENTIATION BETWEEN VARIETIES OF BUSH SNAP BEANS BY CHEMICAL AND PHYSICAL METHODS. W. A. SISTRUNK. *Food Technology* **23,** 80–83 (1969)—Ten varieties and selections of snap beans were chosen to represent regular and Blue Lake types for comparing the differences in carbohydrates at four stages of maturity. The regular bush types were higher in total sugars and starch than Blue Lake types in all sizes. Also, changes in these constituents with maturation were greater in the regular bush types. There were larger quantities of water-soluble pectin in Blue Lake types after canning. Calgon-soluble pectin and cellulose increased more rapidly with an increase in sieve size in regular bush types when analyzed fresh, but less rapidly in protopectin. Sloughing increased with sieve size in canned Blue Lake type beans while it decreased in the large sieve regular bush type.

PROCESSING AND PRESERVATION OF GINGER BY SYRUPING UNDER ATMOSPHERIC CONDITIONS. 1. Preliminary Investigations of Vat Systems. B. I. BROWN. *Food Technology* **23,** 87–91 (1969)—Two vat systems were investigated, one of three vats the other of six vats. Characteristics of each processing system were discussed, with respect to percent total soluble solids, vat temperature, texture and color of the processed product, syrup pH and flowrate, percent weight increase, and sucrose:reducing sugar ratios of syrup during processing. Optimum conditions for processing required a constant vat temperature of 125°F to 135°F with continuous flow of syrup through the vat system.

ECOSYSTEMS OF FOOD-CONTRACT SURFACES. S. K. CHATURVEDI & R. B. MAXCY. *Food Technology* **23,** 67–70 (1969)—An ecosystem to simulate food contact surfaces was studied. Factors other than nutrients played major roles in the survival and growth of the microflora. Surfaces, surface interaction with soil, and surface-sanitizer-soil interaction were major factors influencing the fate of the microflora. Even with films of milk soil visible to the naked eye, the microflora of raw milk showed a population decrease without selectively dominant survival groups.

DETERMINING THE EMULSIFYING AND EMULSION STABILIZING CAPACITY OF PROTEIN MEAT ADDITIVES. P. A. INKLAAR & J. FORTUIN. *Food Technology* **23,** 103–107 (1969)—The four additives studied were: two brands of isolated soy protein, sodium caseinate and a soy concentrate. The influence of several variables in the described method, such as dispersion time of the protein, quantities of water, oil and protein, temperature, variation in the manufacture of the emulsion, were studied. The results obtained with the proposed method are generally in agreement with those obtained in sausage manufacture, as far as fat separation is concerned.

MICROBIAL PROFILES OF FRESH BEEF. W. C. STRINGER, M. E. BILSKIE & H. D. NAUMANN. *Food Technology* **23,** 97–102 (1969)—Immediately after slaughtering, carcasses contained high levels of microbial contamination and moister carcass areas were the most highly contaminated. The amount of contamination increased slightly after chilling and there was a larger increase during transportation to the retail store. The logarithm of the mean counts per in.^{2} from the areas sampled was 4.70 after slaughter, 4.78 prior to shipment from the plant and 5.94 on arrival at the retail store.

DISCOLORATION OF EGG ALBUMEN IN HARD-COOKED EGGS. R. C. BAKER & J. DARFLER. *Food Technology* **23,** 77–79 (1969)—Eggs, 1 day and 1 week old, were cooked in boiling water for 12 min, then held in water at 60, 70 and 80°C up to 25 hr. Results, using a color difference meter, show the following factors increase the caramel color occurring in the albumen: high holding temperatures, long holding times and old eggs. The discoloration was found to be caused by the carbonyl amine browning reaction (Maillard reaction) due to the proteins and glucose present in the egg albumen.

technology

COLOR / *on the Move . . .*

Color Problem 10: Is It Yours?

• U. California—Berkeley . . . . The Inter-Society Color Council has established a special Sub-Committee on Problem 10: "Color Aptitude Test." IFT-er Angela C. Little is co-chairman of the subcommittee. Is this test of interest to you?

Some of the questions the sub-committee will attempt to answer are these:

What do the various color discrimination tests really measure? Do any of the tests measure innate ability? How are the results affected by training and experience? Would a Hue Discrimination Test patterned after the present Saturation Discrimination Test correlate with ISCC-CAT? with F-M100? How valid are the present tests in predicting ability to meet specific job requirements?

State your concern or experience to A. C. Little, Dept. of Nutritional Sciences, U. Calif., Berkeley 94720.

Discoloration of Canned Wax Beans

• Cornell U.—Geneva, N.Y. . . . . Packaging of wax beans in enameled cans gives the product a darker and less yellow appearance than that packed in plain tinned cans. As little as 5 ppm ferric ion causes considerable darkening, and color defects are severe when 100 ppm are present.

The effect of ferric ions on enameled can packed wax beans could be reversed using 4 ppm of stannous ion, or 50 ppm EDTA, or 400 ppm citric acid. A higher concentration of bivalent tin ion (80–100 ppm) produced the lightest wax beans in enameled cans.

Discoloration of Egg Albumen

• Cornell U.—Ithaca, N.Y. . . . . The longer eggs are held before cooking, the more their albumen is prone to discoloration. Also, holding at elevated temperature after cooking causes earlier onset of discoloration.

The nature of the color development was shown to be the browning reaction between carbonyl and amino groups respectively of glucose and albumen proteins. Enzymatic removal of glucose prevents discoloration.

Eggs hard-cooked should be from fresh stock and should be cooled immediately after cooking.

Old World Monkey Normal Vision New World Monkey Hasn't

• Indiana U./U. Texas—Bloomington/Austin . . . Experts respectively on old world macaque monkeys and new world squirrel monkeys pooled their efforts. They came up with the thought that these two kinds of primates may have different ancestors, since their vision is so unlike.

Macaque monkeys are nearly identical in vision to normal-vision humans. The mechanism of color perception is through the output of three kinds of cones (max. absorption at three wavelengths) via an information channel of nonopponent cells in which this output is added to indicate whiteness-blackness of a light. The same channel also determines brightness. In other channels of opponent cells, output from one of the three cones is subtracted from output of another, in various combinations, to signal the hue of the light. The ratio of activity respectively in opponent and nonopponent cells gives a measure of saturation.

Squirrel monkeys and protanomalous humans have color vision that is weak and deviates from the normal. Weakness is attributed to a relatively smaller number of opponent cells, and deviation comes from having two kinds of cones instead of three, each absorbing at different wavelengths.

Color Enhancement from Orange Peel Carotenoids

• Citrus Expt. Sta.—Lake Alfred, Fla. . . . . Workers have perfected a method for extraction, concentration and purification of carotenoids from orange peel.

The resulting product can be added to orange juice concentrate to increase the color and thereby acceptability of the OJ concentrate.

Non-Enzymatic Discoloration of Fruit Products

• Inst. Hortic. Produce—Wageningen, Netherlands . . . . Brown coloration in strawberries as during heat treatment or in storage is accompanied by destruction and/or con-

. . . continued/on page 14 . . .

densation of anthocyanins, sugars, and sugar-amino compounds. Major anthocyanins of strawberry are two red pelargonidins and a purple cyanidin pigments. Using these pigments in model systems with cupric ion and ascorbic acid separately or together, the combination (Cu + AA) gave most rapid discoloration; holding under nitrogen decreased discoloration.

When sugars present in strawberry juice (glucose, fructose, galactose, rhamnose, arabinose) were heated together with glutamic acid, brown coloration was produced, with arabinose yielding the darkest color.

☐ PVP for Non-Selective Anthocyanin Isolation

• Oregon State U.—Corvallis . . . . Common purification procedures for anthocyanin determinations involve precipitation as lead salts or adsorption on cation-exchange resin followed by elution with acidified methanol. The former procedure may involve selective precipitation of anthocyanins having ortho-hydroxyl groups, and the latter ordinarily gives rise to hydrolysis to aglycones.

Insoluble polyvinylpyrrolidone resin contains an oxygen atom in peptide linkage that forms unusually strong hydrogen bonds with the proton of phenolic hydroxyl groups. This property has been utilized in a method of purification in which the anthocyanins are adsorbed non-selectively onto insoluble PVP from a water extract and are subsequently eluted using methanol containing .01% HCl.

Recovery of anthocyanin was approx. 90%, and no evidence of aglycone formation was found.

☐ Sorting Raw Salmon By Flesh Color

• Fisheries Res. Board—Vancouver, B.C. . . . . A fieldworthy reflectance spectrometer has been developed for in-cannery sorting of raw salmon. Measurements could be made more accurate by use of a special glass-covered sample holder and of neutral gray chips as reference standards. Ratio of reflectances at 650 and 570 nm correlated well with visual color evaluation and with Hunter a/b ratio.

☐ Moving Colored Stripes Modify Perception

• McGill U.—Montreal . . . . Students with normal vision and color vision watched alternately light-filter-grid produced green stripes moving up and red stripes moving down.

After exposure for ½ to 4 hours, testing with white stripes moving up and down invoked a direction-specific color after-effect. No color was reported when the grid was held stationary, but a pink after-effect was seen when white stripes moved up, and a green after-effect when they moved down. Longer conditioning exposure to green-up red-down stripes maintained the after-effect for 20 hours.

The conclusion: experience which pairs simple attributes of visual stimulation—color and motion in this case—can result in a lasting modification of perception.

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The MEASUREMENT of COLOR

F. M. CLYDESDALE

THE AUTHOR is with the Department of Food Science and Technology, University of Massachusetts, Amherst, Mass. 01002.

☐ COLORIMETRY or color measurement is simply the means whereby the color of an object may be stated in terms of numerical values.

A common question is: *Why do we have to use instruments and numerical values to describe a color?* The ratîonale for this question is that all we ever do is look at colors, we use our eyes, and that's the end of it.

• Unfortunately—eyes must be present within a *living* body to be used; and all the biases, personality differences and associated human frailties present, subject the color judgment to many different interpretations.

That is one problem associated with a color judgment.

But another one which is equally important is the near impossibility of describing a color in subjective terms; *How red is red?*

Color matching

The need for some sort of objective measurement and specification technique having been established, the next problem which arises is the means to accomplish this.

The best place to begin would be to establish a system to match any given color and then use the components of the system to describe the color numerically.

One of the best matching techniques is achieved by using additive color formulation whereby different colors are produced by superimposing colored lights on a screen.

In practice it will be found that a minimum of three primary colored lights consisting of red, green, and blue will be required to match a given color. This requirement is in part due to the physiological response of the cones of the eye to colored objects.

Simple equipment for one of the most basic and satisfactory methods for matching a color by the addition of lights was first described in some very old experiments, (Newton, 1730; Grassman, 1853), and is shown in Figure 1.

The color to be matched is projected onto a screen and in addition, each of three projectors shines a red, green, and blue primary light, respectively, on the other half of the screen. There is a complete overlapping of the three primaries to create one spot whose color is changed by changing the intensity of red, green, or blue light striking the screen. Thus, the color may be specified mathematically in terms of the intensities of the three primaries required to create a match.

Grassman (1853) also proved that the chromatic function of color could be diagrammed as a two-dimensional plot in which the color function is similar to mass. This became known as "Newton's Law" of color mixture.

This concept may be more easily understood if one visualizes each of the three primary lights, red, green, and blue to be situated at each corner of an equilateral triangle and shining towards the center. Thus, the center of the triangle would be white where all three primaries are mixed equally and in the rest of the triangle each point would have color dependent upon the mixture of lights at that point.

Mathematically the corners of the triangle may be considered to represent 100 percent red (R), 100 percent green (G), and 100 percent blue (B), and any color within the triangle may be located by plotting the amount of each primary color required to obtain a match. The amounts which are represented by the symbols G, R, and B are known as the tristimulus values of the primaries.

Mathematically a right angled triangle is much easier to work with than an equilateral, and this transformation may be carried out easily.

Figure 2 shows one of these right-angled triangles formerly called Maxwell triangles because of his introduction and use of them, and now called chromaticity diagrams.

The primaries used in Figure 2 were selected from the spectrum colors in the red at 700 nm, in the green at 546 nm, and in the blue at 436 nm. The position of white and some of the colors from the spectral locus are also shown in Figure 2.

Unfortunately it was found experimentally that all colors cannot be matched by the addition of three primaries, even if these primaries are spectrum colors. However, this problem can be overcome simply by adding one of the primaries to the test color and matching the combined color by the addition of the other two primaries.

Then, for purposes of describing the test color, the light added to it may be thought of as being subtracted from the other two primaries.

Symposium: COLORIMETRY of FOODS

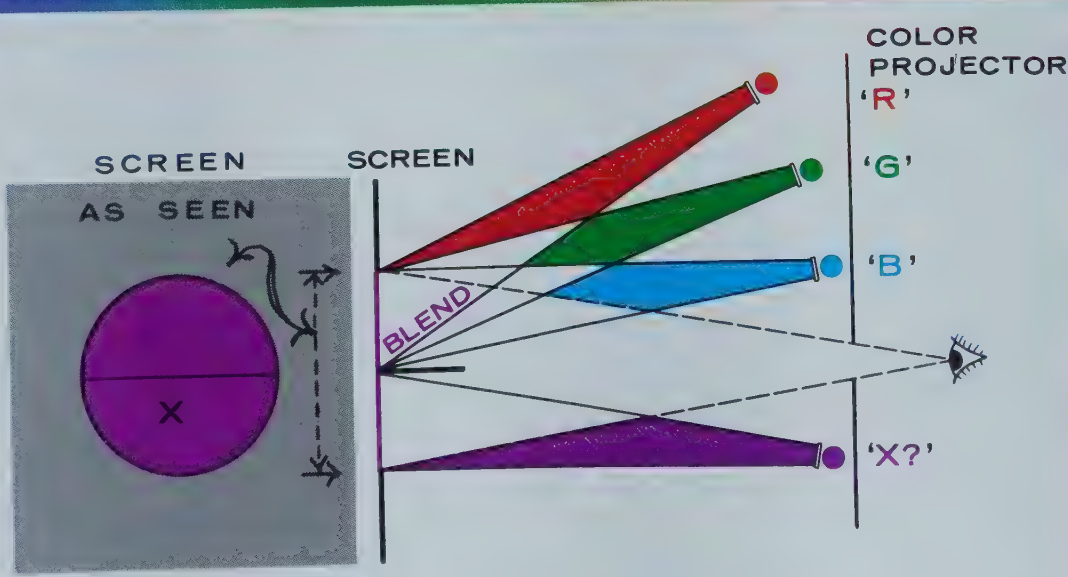

Figure 1—Color matching by the addition of lights. Screen is seen on edge and, to the left of edge, in full view. Arrows indicate area on screen illuminated by lights used for matching (top half of circle) and light to be matched (bottom half, marked "x"). Blending is accomplished by varying the intensity of light from each projector of a primary color; it occurs where the three beams overlap and the word "BLEND" appears. The beam of light from Projector 'X' is not completely filled in with the purple color in order that the diagram might show clearly (in addition to the 4 projectors, their beams, and the region of blending) the total span of the eye as it sees the two halves of the illuminated screen area.

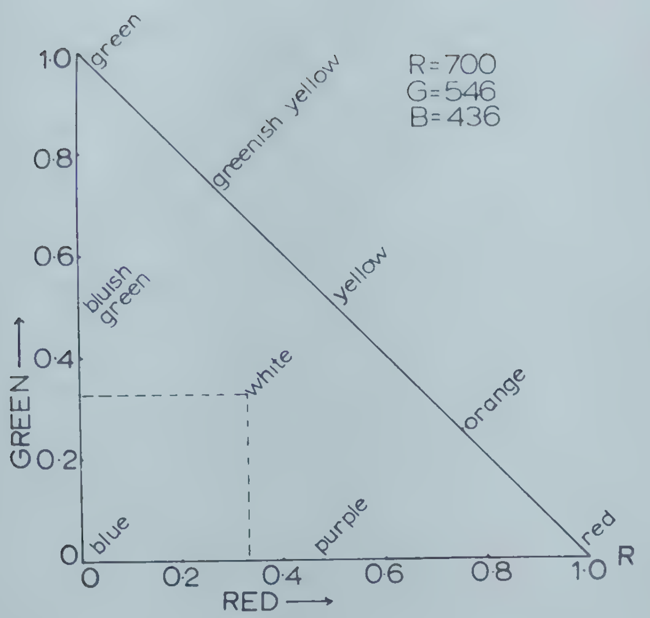

Figure 2—A right-angled G R B chromaticity diagram (Maxwell triangle).

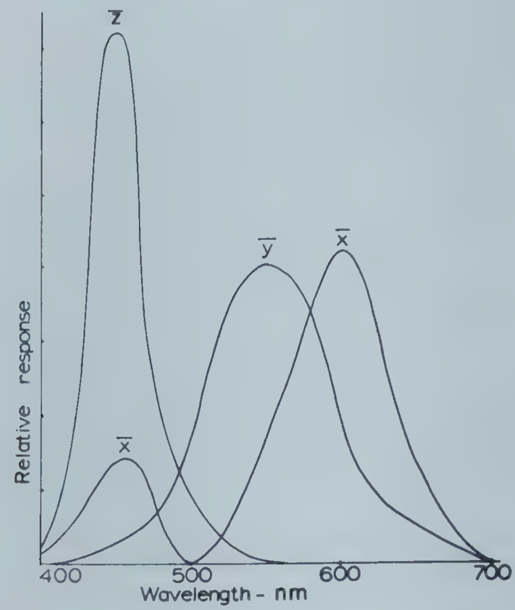

Figure 3—Standard observer curves based on the CIE, X Y Z system.

That is, the test color can be described with a positive amount of two primaries and a negative amount of the third.

In order to develop this concept into a workable system of color measurement it was necessary to reach agreement on two separate issues.

The first of these would be to establish the amounts of the three primaries required to match any color throughout the visible spectrum in terms of a representative population of people with normal color vision.

The second would be to arrive at a suitable mathematical system in order to express the coefficients of the primaries in a manner which facilitated their manipulation as color units.

The standard observer

The first problem resolves itself into the definition of a standard observer's response to the visible spectrum.

Referring back to the type of equipment illustrated in Figure 1, one may see how such standard observer responses may be obtained. If the test light represented a certain wavelength of the visible spectrum, then an observer with normal color vision could match that color by means of additive or subtractive mixing of the three primaries (R), (G), and (B).

This could be done for each wavelength, and the coefficients or tristimulus values of the primaries could be plotted at various wavelengths to obtain standard observer curves for the visible spectrum. The tristimulus values of the standard observer are represented by the symbols $\bar{r}$, $\bar{g}$, and $\bar{b}$.

By using a random sample of persons with normal color vision, average standard observer curves may be developed which represent the physical stimuli causing each color to be perceived by the brain.

The C.I.E. (Commission Internationale de l'Eclairage), which is the most prestigious body concerned with colorimetry, defined color matching characteristics of the standard observer on this basis in 1931. Several modifications in the definition have occurred since then, but the techniques used remained fundamentally the same.

The X Y Z system

Having defined the standard observer curves, the C.I.E. had to consider the second problem which was to define appropriate reference stimuli or tristimulus values.

As stated previously, the use of (R), (G), and (B) involves the use of negative quantities. Negative values of color were unlikely to be appreciated by those who were going to use the system, and also these negative values would complicate the mathematical manipulation of color units and tend to hamper the design of photoelectric instruments equipped with mechanical integrators.

For reasons such as this the C.I.E. decided that, although the (R G B) system was appropriate for defining standard responses, another system of reference stimuli should be developed. Thus, X, Y, and Z were chosen by the C.I.E. as imaginary primary lights for the description of colors.

These primaries were selected so that

a) all possible real colors could be "matched" by positive amounts of the primaries;

b) a relatively large range of colors in the yellow-red region could be "matched" with only two primaries (note in Figure 3 that the $\bar{z}$ curve ends in the yellow region and colors beyond this may be matched by $\bar{x}$ and $\bar{y}$ only); and

c) the intensity (luminosity or lightness) of the light needed to make the "match" is specified by the Y primary alone.

Figure 3 shows the standard observer curve in terms of $\bar{x}$, $\bar{y}$, $\bar{z}$. These curves were developed from $\bar{g}$, $\bar{r}$, $\bar{b}$ standard observer curves, and it should be emphasized that although $\bar{x}$, $\bar{y}$, $\bar{z}$ may be calculated from $\bar{g}$, $\bar{r}$, $\bar{b}$ experimental data, the **X**, Y, Z values cannot be produced experimentally.

Figure 4 shows the type of projection required to mathematically transform the G, R, B triangle to the **X**, Y, Z system, which includes all possible colors and also shows that the rather odd shaped **X**, Y, Z triangle may be transformed into a right-angled triangle creating positive values of **X**, Y and Z.

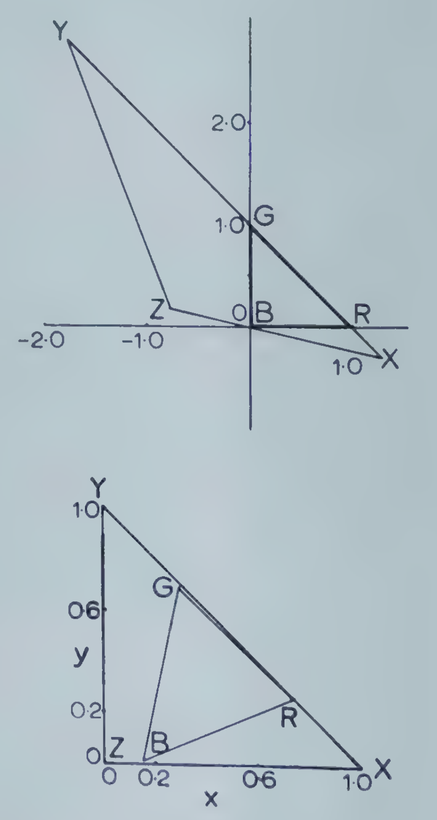

Figure 4—Transformation of the G R B to the X Y Z chromaticity diagrams. The bottom diagram is the X Y Z obtuse triangle transformed into a right-angled triangle.

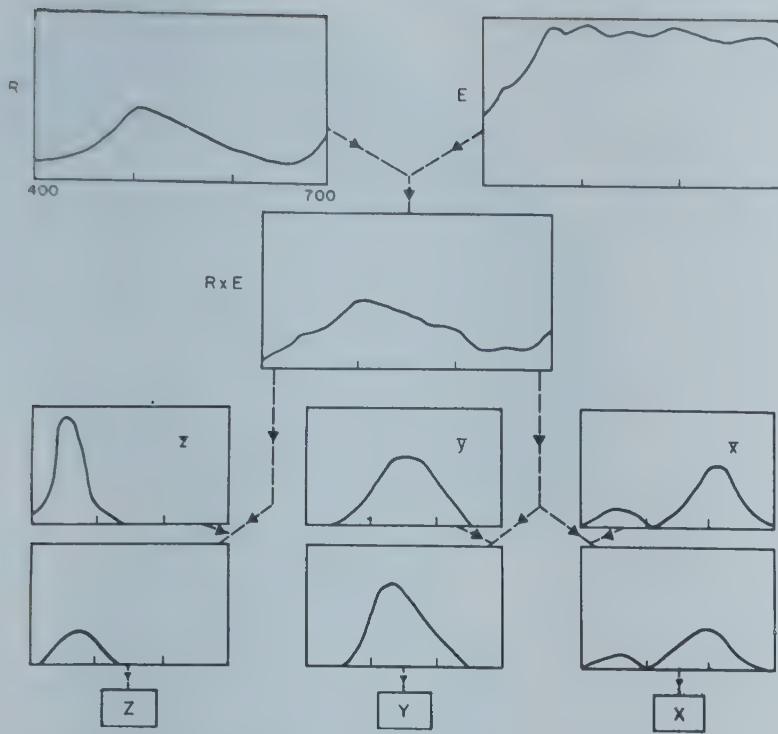

Figure 5—A diagrammatic illustration of the calculation of the X, Y, and Z primaries.

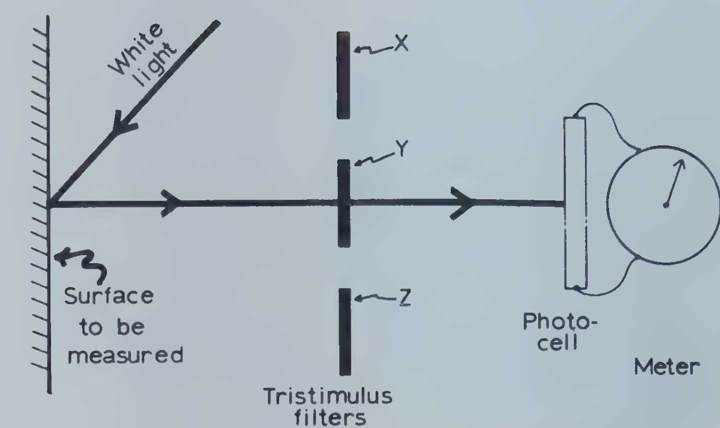

Figure 6—A simple tristimulus colorimeter.

Objective measurement techniques

All experiments which have been described thus far have depended upon a human judgment to predict a color match in order to describe a color.

In order to eliminate human judgment the principles developed thus far must be replaced by an instrument.

Color normally involves three components: a source of light, an illuminated object (the color of which is to be described), and an observer. The C.I.E. system, as previously described, provides a standard observer response and also a specification of a standard source in terms of C.I.E. Standard Sources A, B, and C simulating incandescent light, noon sunlight and overcast daylight respectively. The third factor, an illuminated object, is of course, the test color to be measured.

Actual instrumental measurement may be divided into two parts: 1) spectrophotometry and 2) tristimulus colorimetry.

Consider spectrophotometric measurement of color using the C.I.E. system. An instrumental measurement must measure the physical stimuli in terms of how the eye sees color. The instrument achieves this by using either one of two different arrangements of standard source, test sample and photodetector.

One is named O, 45° viewing and is achieved by measuring the light which reflects off the test sample from the source at an angle of 45°. This is known as diffuse reflection and is mainly a function of color.

The other arrangement involves the use of an integrating sphere, which is a hollow metal sphere painted white inside. An integrating sphere collects all the light reflected from the surface of a sample placed against an opening (commonly called a port) in its side. The light collected for measurement may or may not include specular reflection (mainly a function of gloss) along with the diffuse reflection. Both of these methods are used, but unfortunately they do not give identical results for all types of samples.

Readings are obtained over the visible spectrum and a spectral response curve for the test sample is obtained. This response is symbolized by R.

The monochromatic light used is a C.I.E. standard source that has a defined spectral curve of its own. The energy elicited at every wavelength of this curve is symbolized by E. Thus the total energy received by the phototube is the product RE.

In order to obtain values analogous to what the eye sees, this energy function RE must be multiplied by the functions $\bar{x}$, $\bar{y}$, and $\bar{z}$, of the standard observer curve, respectively. The multiplication may take place at intervals across the visible spectrum, so that at any one wavelength, $X = RE\bar{x}$, $Y = RE\bar{y}$, and $Z = RE\bar{z}$.

If the wavelength interval across the visible spectrum was $d\lambda$ then the color of the object may be specified by integrating between 380 and 750 nm as follows:

$$X = \int_{380}^{750} RE\bar{x}\,d\lambda$$

$$Y = \int_{380}^{750} RE\bar{y}\,d\lambda$$

$$Z = \int_{380}^{750} RE\bar{z}\,d\lambda$$

Figure 5 shows this operation in a diagrammatic manner that might be easier to understand.

The integrals could be calculated manually, but normally instruments have a mechanical integrator which carries out these operations so that a direct read-out of the tristimulus values X, Y, and Z is obtained.

In order to obtain the tristimulus coefficients or chromaticity coordinates, these values are merely expressed as fractions of their total so that

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z}$$

The second type of instrumental color measurement is that obtained using a tristimulus colorimeter. In this case the integration procedure using standard observer curves is replaced by using filters which simulate the $\bar{x}$, $\bar{y}$, and $\bar{z}$ curves respectively, as shown in Figure 6.

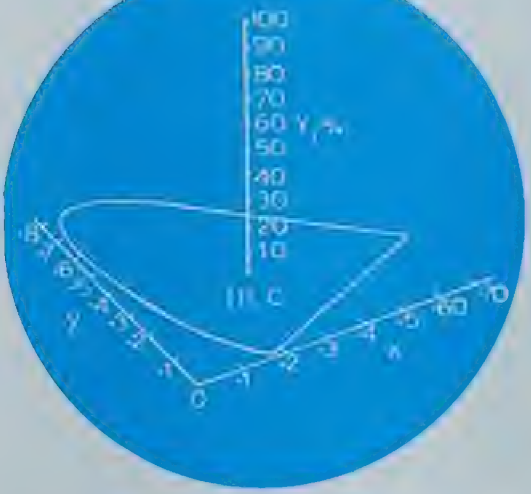

Figure 7—The CIE x-y chromaticity diagram showing percent Y.

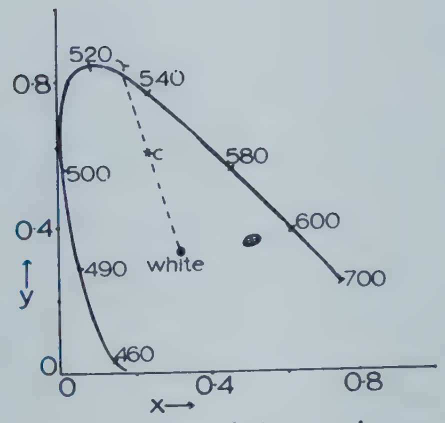

Figure 8—The CIE x-y chromaticity diagram showing dominant wavelength and purity.

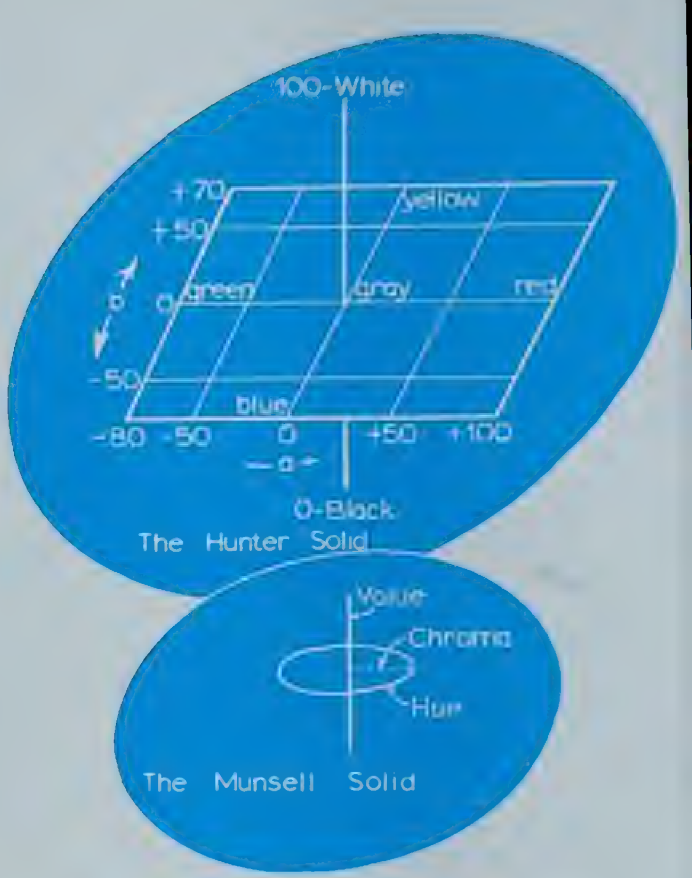

Figure 9—The Hunter and Munsell solids.

x-y Chromaticity diagram

At this point it is becoming obvious that the physical stimuli responsible for color can be expressed in mathematical terms. However, an explanation of what these terms represent is in order.

When a color is specified in terms of tristimulus values, it means that the color is being located in three-dimensional space. One method of visualizing this is shown in Figure 7 where the spectral colors are plotted on x, y coordinates to obtain the C.I.E. horseshoe shaped spectrum locus. All colors fall within this locus but, in order to obtain a point in three-dimensional space, % Y (specified as the brightness or luminosity function) is also plotted. This means that any color may be specified in three dimensional space by a statement of x, y, and % Y.

In addition to defining the area over which physical stimuli must be located, the spectrum locus provides a greater meaning to the color quality associated with any point within it. Thus, in Figure 8, if a straight line is drawn from the illuminant point (white) through C to intersect the spectrum locus at λ, we know from the geometry of the chart that a suitable mixture of λ and the illuminant will match C. If the hues of the spectrum are familiar to the color worker, the value of λ will give an idea of the hue of C, while the distance of C along the line from the illuminant towards λ will give an indication of its chroma or intensity.

The point λ is known as the dominant wavelength of the color C, and the ratio of the distance from the illuminant to C over the distance from the illuminant to the spectrum locus at the dominant wavelength is known as the purity of the color C.

The specification of dominant wavelength and purity will thus allow a somewhat better visualization of the color than the tristimulus values.

Colorimetric solids

Colorimeter readings, however, do not have to be expressed in terms of X, Y and Z.

One of the simplest set of scales is that in which a pure white sample (MgO or $BaSO_4$) is taken to read 100 when viewed through each of the filters. Readings obtained are often called G for green corresponding to C.I.E. tristimulus value Y, R for red, related to the large peak of the X curve, and B for blue related to the Z curve.

In an instrument of this type (three filters), values of X, Y, and Z can be approximated by adding a fraction of the B reading to the R reading in order to compensate for the small peak of the X curve. Then the modified R reading plus the G and B readings may be multiplied by appropriate factors to obtain tristimulus values. C.I.E. Y for MgO is 100 so that when the G value is set to 100 it becomes equal to Y by definition. Adding a fraction of the B reading to the R reading assumes that the small peak of the **X** curve is the same shape as the Z curve. This is not strictly correct and therefore some instruments use a fourth filter, R′, to simulate the small peak of the **X** curve. Tristimulus values are then calculated in the same manner as above.

Another common set of scales developed by Hunter (1942) are used on some instruments. These produce results in terms of L, which is a lightness function and simulates Y; a, which predicts redness if positive and greenness if negative, and b which predicts yellowness if positive and blueness if negative. A diagrammatic representation of the Hunter solid is shown in Figure 9.

All conversions described above are calculated within the instrument, so that direct read-outs are obtained.

Figure 9 also shows the three functions which make up the Munsell solid. This is perhaps the best known of all the color order systems. It is a system which attempted to create painted colors to represent equal intervals of visual perception of color differences between adjacent samples and also to specify these colors in terms of its three coordinates; *hue, value,* and *chroma.*

• Hue describes what the average person thinks of when he speaks of

color, i.e. red, yellow, green, blue etc.

- Value describes the lightness or darkness of the color.
- Chroma describes intensity.

As may be seen in Figure 9, hue is represented on the horizontal circumference of the solid, value is the vertical central axis and chroma is described in units measured outward from the central axis.

This system is as close to equal visual perception as any devised. Obviously the reason for this is that the colors of the solid were painted with this in mind.

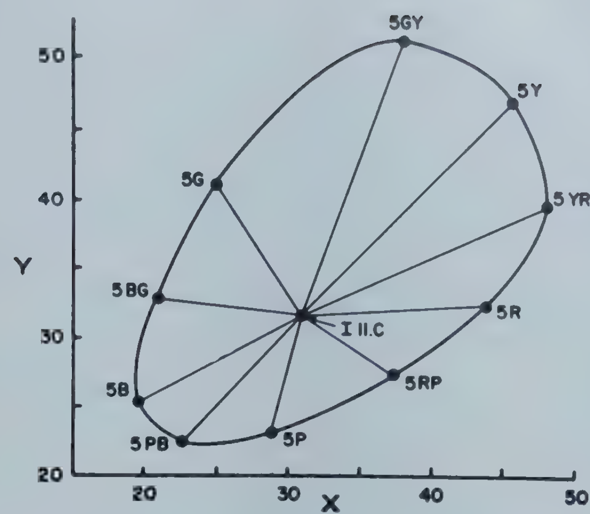

Figure 10—A portion of the CIE chromaticity diagram, showing the locations of the Munsell colors at the ten major hues, value 5, and chroma 8.

Uniform chromaticity

If the C.I.E. system simulated the eye exactly, then one would expect that equi-distant colors representing a circle in the Munsell system would also form a circle in the C.I.E. system. Unfortunately, when the tristimulus coefficients x and y of the Munsell colors are calculated and plotted on a chromaticity diagram as in Figure 10, the resulting plot is not a perfect circle.

Many systems have been developed in an attempt to improve the visual spacing of the C.I.E. system. One of the first was the Uniform Chromaticity Scale (UCS System) of Judd (1935). Breckenridge et al. (1939) developed this into the rectangular UCS system (RUCS). MacAdam (1937) developed the u, v system and later another system (MacAdam, 1943) for the calculation of small color differences. The system developed by Hunter (1942) is closely related to the read-outs of Hunter instruments.

Other systems, by various methods, have attempted to simulate the visual spacing of the Munsell system.

- A partial list might include the Adams Chromatic Value System (Adams, 1942); the Omega Space of Moon and Spencer (Moon et al., 1943a, 1943b); the Saunderson-Milner Zeta Space (Saunderson et al., 1946); the Din System (Richter, 1955); the Glasser System (Glasser, 1958) and the Adjusted Hue System of Billmeyer (1961). None of these systems were completely successful and there is some question as to the real advantage of having visual uniform spacing as long as small color differences can be specified.

Color measuring instruments in fact are best used to predict color differences between samples and are misused when they are employed to measure the absolute color of a sample.

Subjective measurement techniques

Thus far, equipment described has used a photoelectric system to specify the measurement of a color.

There is no reason why the eye could not be used, instead of a photocell, as a detector. In fact there are several techniques which are based upon the eye as a detector.

These methods may run the gamut from disc colorimetry (Nickerson, 1957) to color comparators, to the use of standardized glass filters whose combinations form the units which specify the color to refined spectrometers or colorimeters using the eye as a detector.

Reduction of data

Since color measurement basically consists of the specification of a point in three-dimensional space, it is logical to assume that the value of each of the three coordinates will change as the color is changed.

Under normal circumstances, however, such as in quality control, it would be advantageous to have only one or two variables, rather than three. If only one or two of the variables are used, there is normally going to be a corresponding decrease in the accuracy of the measurement made. Therefore, it is the operator's choice to decide if the extent of the increase in accuracy justifies the computations involved with the use of three variables.

It should be emphasized that any function of color used for a particular product should first be correlated with a subjective panel of visual judgments. At times there is a tendency to use a function which describes visual judgment for one product on a completely different product. This is a dangerous practice and the literature shows that most single functions which combine the color coordinates are recommended for a single product.

Examples of this may be seen in the function

$$\frac{a_L}{\sqrt{a_2^2 + b_2^2}} \Big/ L$$

developed by Yeatman et al. (1960) used for grading tomato juice and in the recommendation of Francis (1952) to use the function $\tan^{-1}a/b$ rather than a/b when measuring the color of apples.

Another type of specification used in color work is the specification of color differences between samples, expressed as a single value.

There are many methods by which this color difference may be specified, but it should be remembered that a color difference score relates the total distance two colors are apart in color space, but does not specify the direction one is in relation to the other. This means that other functions which relate a direction should be used in conjunction with a color difference score.

At times it is convenient to transform one set of tristimulus values to another. Thus, one might specify the degree of greenness or redness by $-a$ or $+a$ respectively rather than specifying three tristimulus values of X, Y, and Z. This is completely legitimate, and there are transformation

equations available to do this operation. However, these equations are based on opaque standards, and as Clydesdale et al. (1968) have pointed out, do not always function as well with translucent food materials.

It should be apparent that color measurement at this stage of its development is an invaluble aid to the Food Scientist. However, as is the case with most technologically advanced "aids," its use should be tempered with a heavy dose of judgment and reason.

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Paper presented in the Symposium "Colorimetry of Foods" at the 28th Annual Meeting of the Institute of Food Technologists in Philadelphia.

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IFT Joins ISCC

Early last year, the Institute of Food Technologists joined numerous other scientific and technical organizations to become a member of the Inter-Society Color Council.

The Council is a meeting ground for gathering and disseminating all kinds of color problems and advances, and IFT members working with food color may benefit from this new association.

Chairman of IFT's delegation to ISCC is Prof. Gordon Mackinney (Dept. of Nutritional Sciences, Univ. of California, Berkeley, Cal. 94720). Other members of the delegation include F. J. Francis, J. N. Yeatman, A. Kramer, A. C. Little and H. J. Peppler.

IFT'ers wishing to advise their interest in and specific problems with color should communicate with the chairman of IFT's delegation.

A Congress No. 1

The First Congress of the International Color Association will be held June 9–13 at the Royal Institute of Technology in Stockholm, Sweden.

Topics of the Congress will be color vision, psychology of perception, colorimetry, teaching of color, and color technology. An exhibit will be part of the Congress.

For further information write to Color 69, Fack, S-104 50 Stockholm 80, Sweden.

Dutch Horticulture: Tomatoes and Apples

Color grading of tomatoes is a difficult matter. It is not enough to distinguish between an acceptable color and one that is not, but shades of color and relation to time when color development will be complete are also important.

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. . . more/on page 28 . . .

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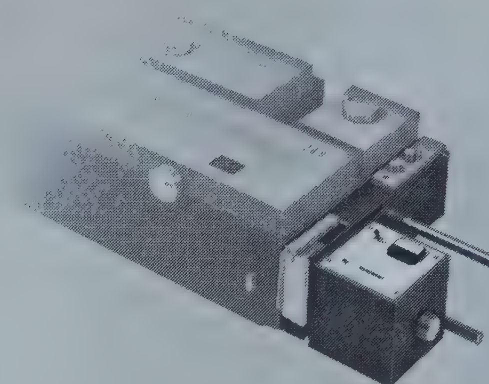

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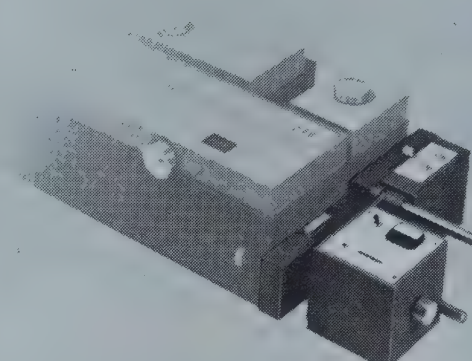

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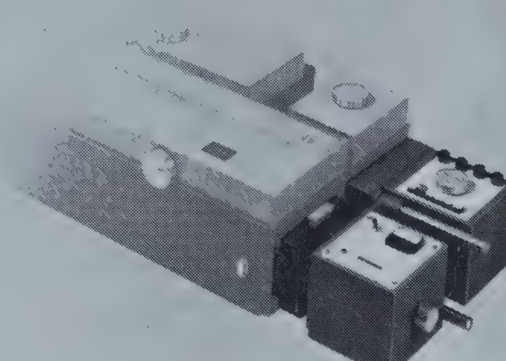

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2. The SAMPLE as a PROBLEM

ANGELA C. LITTLE and GORDON MACKINNEY

THE AUTHORS are with the Department of Nutritional Sciences, University of California, Berkeley, Calif. 94720.

☐ OVER THE LAST four decades, many advances have taken place in the development of the science of colorimetry.

The tools and techniques for measuring the spectral distribution of light emitted by, transmitted by, or reflected from objects have reached a high level of sophistication.

Systems of specifying color stimulus equivalents have been defined in terms of the additive mixture of three designated primaries (tristimulus values), the spectral power distribution of a standard light source, and the calculated response of a standard observer. These terms are defined elsewhere in this issue (see article beginning on page 16).

Such specifications state that under defined conditions of illumination and viewing, one and only one combination of the three primaries will be accepted as a match to a given color stimulus by the standard observer.

All color stimuli with the same tristimulus values under the defined conditions will in turn match each other whether or not they have the same spectral distribution characteristics. Such systems do not give direct information regarding color appearance, i.e. they do not specify color *per se*.

The major importance of the colorimetric specifications lies in their ability to evaluate color stimuli on a psychophysical basis in terms of equivalent stimuli for the purpose of determining color matches, color differences and color changes.

It may seem of little consequence to belabor a distinction between the terms "color stimulus equivalents specification" and "color specification" as applied to tristimulus values derived from instrumental measurements. The distinction is stressed here, however, in support of the point of view that *the measurement of the light-modifying properties of an object does not qualify as a measurement of color,* nor does the statement that stimulus A matches stimulus B qualify as a specification of color.

Human & instrumental response

Color belongs to visual experience; it is not an inherent characteristic of an object. The object merely emits, transmits or reflects light of a certain spectral distribution which is translated by the eye, nerve, brain complex to a color response. The stimulus, i.e. the light-emitting or light-modifying properties of the object, can be precisely and accurately measured by instrumental means. The response can not. It can only be evaluated in terms of psychological scales which then become measures of color.

The establishment of a relationship between the stimulus and the response is accomplished through psychophysical scaling techniques. Thus in the CIE tristimulus system the physical characteristics of the light stimulus are translated to tristimulus specifications by incorporation of the color mixing functions of a standard observer.

According to the requirements of the case, one measures either the spectral characteristics of the object as a function of wavelength by spectrophotometry or spectroradiometry, (subsequently or simultaneously reducing the data to the colorimetric specification), or one measures the reflectance of transmittance characteristics of the object directly (in terms of the colorimetric specification) by tristimulus colorimetry.

In either case, the process of measurement is commonly referred to as "color measurement," when in fact it is only the light-modifying properties of the object which are measured with the results expressed in terms of a matching combination of primaries, given a standard observer and specified conditions of illumination and viewing.

Colorimetry for processing

In areas of application of colorimetry where color matching is a prime requisite, it is essential to obtain the characteristics of the total stimulus for purposes of manufacturing materials to designated colorimetric specifications within defined tolerance limits. A few examples can be cited: dyeing of fabrics, manufacture of ceramics, plastics, glass, paints and chemical coatings. The requirement may be that two unlike materials with dissimilar spectral characteristics must match in color, e.g. a painted surface and a dyed textile. In such cases, tristimulus colorimetry provides a useful tool in controlling color matching.

With foods, the problem is not often one of manufacturing samples to conform to a colorimetric specification within small tolerances; it is frequently one of evaluating samples as they exist, for purposes of selection to meet certain requirements.

The requirement may lie in the selections of raw material, in color retention or color development during processing, in detecting deteriorative changes, in meeting marketing specifications. The problems thus generated are frequently very different from each other. The solution may lie in measuring reflectance characteristics using only one broad band filter, or it may lie in obtaining the characteristics of the total stimulus and the colorimetric specifications if information relating to the chemical and physical state of the sample is desired along with information relat-

ing to visual color perception.

However simple or complex the solution may be, the term "color measurement" is also commonly used to refer to the measurement of some part or parts of the stimulus characteristics of the sample. According to the argument presented above, such measurements do not qualify as "color measurements." They should be regarded as a means whereby the measured quantities can be used to predict a sensorily perceived attribute, namely color, while serving at the same time to yield information relating to the physical and chemical state of the sample.

The instrument analyzes the qualitative and quantitative distribution of light transmitted or reflected by the sample; the eye synthesizes the light incident on the retina to the resultant total color response.

Undoubtedly, measurements of stimulus characteristics of objects will continue to be referred to as color measurements according to the dictates of habit and custom. This is of little consequence so long as the term is used with the proper mental reservation, expressed here by use of quotation marks; viz "color measurement."

Methodology for precision

In any analytical procedure, methodology is based on a sequence of operations from which the relevant information can be extracted.

The operational steps must be defined in detail and executed properly in order that results can be placed on a comparable basis. They include the various laboratory manipulations involved in preparation of the sample for analysis and the instrumentation needed to effect the desired analysis. These are old principles with a long history of acceptance in analytical laboratories. These principles, however, have not yet been generally accepted in laboratories concerned with "color measurement" of foods.

The results obtained from measuring reflectance or transmittance characteristics of foods will be affected by the physical state of the sample (sliced, ground, puréed, compressed, extracted, etc.), the method of presentation of the sample to the instrument and the selection of instrumentation. The development of methodology involves not only the control of these factors to insure precise, reproducible results but also the establishment of the link between the analyzed dimensions and visual response by psychophysical scaling techniques.

Attention is confined here to the sample with respect to the problems generated by the physical characteristics, illustrated by specific examples.

Sample preparation

The preparation of a sample for purposes of measurement of color characteristics may be dictated by the specific requirements for which it is being evaluated. This ranges from the absolute restriction that the sample be intact and unaltered to a wide latitude of freedom in sample alteration.

In the case of selection of raw materials, the objective is a rapid, preferably on-line, evaluation of unaltered or minimally altered samples.

Here, the problem becomes one of designing or adapting instrumentation on a single commodity basis to give an immediate decision of accept or reject.

Aside from the special case of raw materials selection, the rationale for measuring intact, unaltered samples is reduced to a minimum. The extent to which the sample has been altered for purposes of analysis is inconsequential provided the quantities give valid answers to the relevant questions concerning the intact sample.

The questions may vary according to the purpose for which the sample is evaluated. The information needed for quality control purposes during processing may be quite different and probably less extensive than that needed for storage study purposes with the same product.

Indeed, for quality control a rapid analytical method becomes mandatory; time as a limiting factor is less important in other applications.

The important considerations that must be given to the development of a procedure are the rapidity with which the analysis must be done and the kind and extent of the information that must be derived from it.

Effect of physical state of sample

The physical state of food samples covers a wide gamut, from powders and granulated materials to liquids; from whole fruits and vegetables to purées and gels; from cuts of meats and fish to sausages and ground or minced products; from solid bricks to porous loaves.

In general, foods show inhomogeneous pigment distribution, irregularities in size, shape, texture, particle size and surface characteristics and can be light-transmitting as well as light-reflecting. The ideal sample for measuring reflectance characteristics is flat, homogeneously pigmented, opaque, and light-diffusing. With the possible exception of products such as brick cheeses, foods do not meet these criteria. Ideal samples for transmittance measurements are non-turbid and moderately light-absorbing. These criteria, too, are difficult to meet.

A close approximation to the ideal reflecting surface is found in dry, powdered materials such as flour compressed into a pellet. Products, such as coffee beans, can be ground and compressed, but here, the major difficulty lies in particle size distribution and the amount of pressure exerted in forming the pellet.

The results can be grossly affected by variations in sample preparation, as was shown by Little et al. (1956; 1958; 1960) in a study on the color of roasted coffee.

The solution lies in standardizing the technique to attain uniform particle size distribution and to control the conditions of pellet formation.

Berardi et al. (1966) have reported on a method of compressing dried food samples between thin discs of Teflon. Successive preparations of such wafers show highly reproducible reflectance characteristics. The authors state that the procedure offers the food industry a rapid, reproducible interlaboratory tool for the measurement of color characteristics of a variety of foods such as lyopholized egg whites or yolks, instant coffee, sweet potato flakes, and gelatin desserts.

Thin layer techniques

Homogenization of samples with high moisture content can be effected by blending, sieving or other suitable means.

Measurements of the surface reflectance characteristics of puréed samples are seriously affected by their translucency. The application of colorant layer techniques to the evaluation of optical properties of translucent purées and liquid samples has been proposed (Little, 1964; Little, 1965; Mackinney et al., 1966; Joslyn et al., 1967). A study of the effect of depth of layer on the measured characteristics of a wide variety of samples is currently in progress (F. J. Francis, private communication). While the proposed technique can serve as a simple rapid means of separating samples in color space, the results of measurements of thin layers against white and black backgrounds can also yield information relating to reflectivity of infinite depth, internal transmittance of light, scat-

. . . the sample as a problem . . .

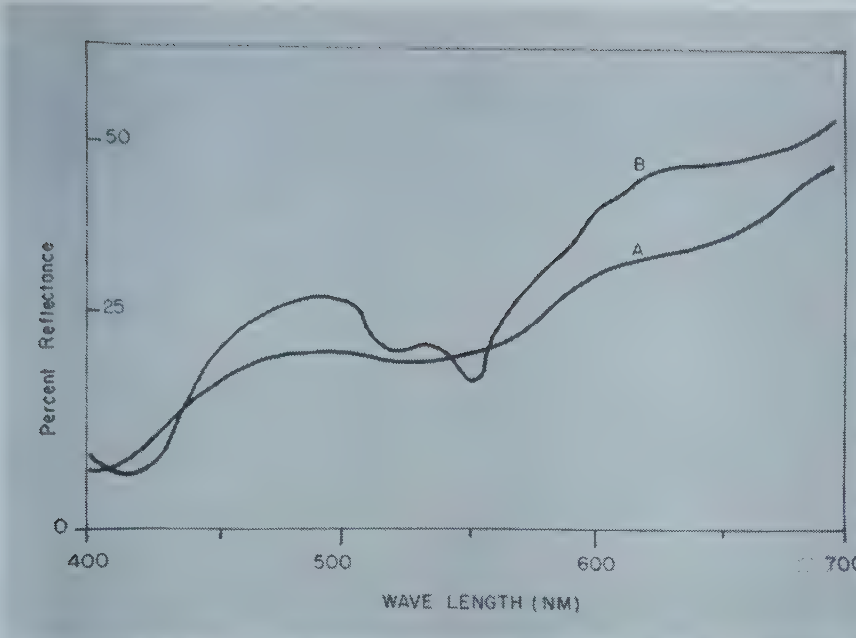

Figure 1—Reflectance spectra of canned tuna. A = Untreated sample. B = Sample treated with sodium dithionite.

tering and absorption coefficients, relative pigment concentration, occurrence of browning or scorching as reported in the papers cited above.

An interesting application of thin layer spectroreflectometry was reported by Elliot (1967) who found that increased sensitivity in differentiating color differences among samples of pork muscle is obtained when 4 mm sections of muscle backed by a white reflector are measured spectrophotometrically. Improved spectral resolution of the pigment characteristics is also obtained using thin samples.

Masking—a problem

A study of the reflectance characteristics of canned tuna currently in progress in this laboratory has led to the observation that homogenized samples invariably show spectral reflectance curves almost completely devoid of the maxima and minima characteristic of the ferrohemochrome even when sample preparation is conducted in an inert atmosphere and the sample is subsequently protected from oxygen on presentation to the instrument (Fig. 1, curve A). The spectral characteristics of the heme system become apparent on treatment of the surface of the sample with sodium dithionite (Fig. 1, curve B). Loss of spectral resolution does not affect the objective evaluation of tuna as it relates to visual experience. It does, however, mask information concerning the state of the pigment in the system. It becomes a limiting factor, therefore, in the amount of information that can be extracted from the analytical procedure.

The reason for the obliteration of the spectral characteristics of the heme system on homogenization of the sample in an inert atmosphere can not at this time be definitively stated. The explanation may lie in the physical relationship of the pigment system to the muscle fiber matrix with which it is associated. The cellular matrix can be considered as a spectrally non-selective light-scattering medium with scattering coefficients, $S\lambda$. The pigment system selectively absorbs light, with absorption coefficients, $K\lambda$. The value of the ratio $S\lambda/K\lambda$ becomes critical. With $S\lambda/K\lambda$ large, the scattering effect of the cellular matrix may mask the pigment effect, $K\lambda$. As $K\lambda$ increases on treatment with dithionite, the ratio $S\lambda/K\lambda$ decreases, thus reducing the masking effect of the background. The discussion by Judd et al. (1963) on reflectivity, $R\infty$, as a function of composition for mixtures of a non-light-scattering black colorant with a non-light-absorbing white colorant provided the stimulus for the development of the above hypothesis.

It is of interest to note that spectral reflectance curves of canned salmon reported by Bolton et al. (1967) are also essentially nondescript.

Support of the hypothesis is found in a study of the effect of a light-scattering background on the spectral reflectance characteristics of water-dispersible β-carotene applied to the background.

Results from one experiment where β-carotene suspensions were applied to filter paper are shown in Figure 2.

Figure 3 represents the total transmittance spectra (transmission and scattering) of the same series of β-

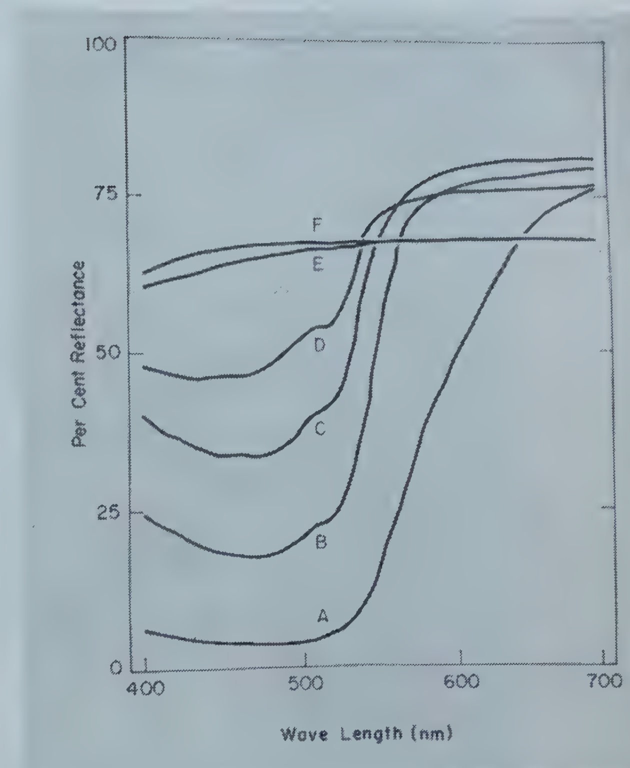

Figure 2—Reflectance spectra of β-carotene suspensions applied to filter paper. A–E = Order of decreasing concentration of β-carotene suspensions. F = Reflectance spectrum of the filter paper.

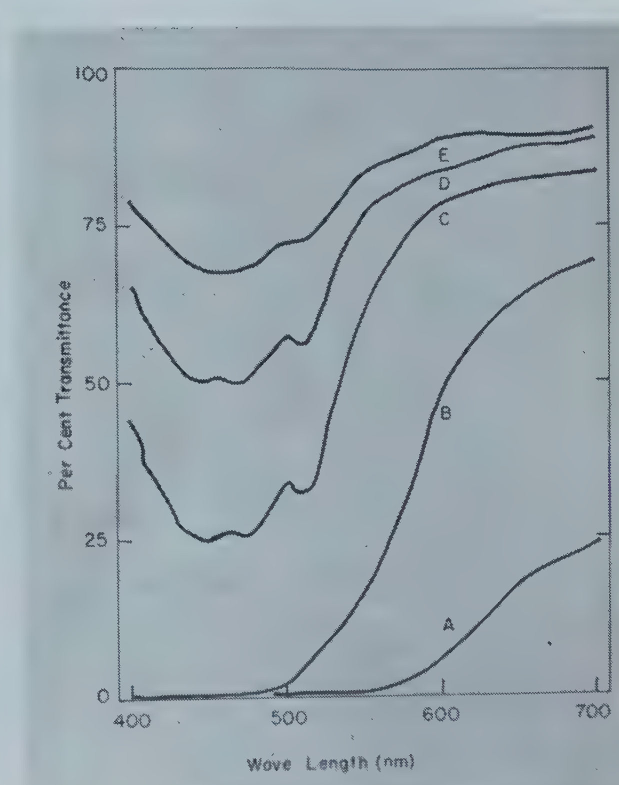

Figure 3—Transmittance spectra of β-carotene suspensions. A–E = Order of decreasing concentration of β-carotene suspensions.

carotene suspensions as measured by a Beckman-DK2 spectrophotometer with integrating sphere.

The reflectance and transmittance spectra of the most concentrated suspensions (Fig. 2, curve A and Fig. 3, curve A), show none of the selective absorption maxima of β-carotene simply because the resolving ability of the instrument has been exceeded.

On dilution, the spectral characteristics of the pigment become apparent. They persist in the case of the transmittance spectra to the most dilute suspensions measured.

In contrast, curve E in Fig. 2, obtained with a dilute suspension, shows that the background light-scattering effect has prevailed and the resulting spectral reflectance curve closely approximates that of the untreated filter paper, curve F.

Qualitative and quantitative differences are obtained when dilute suspensions are superimposed on a variety of backgrounds (filter paper, coarse cellulose tissue, barium sulfate) with the characteristics of the backgrounds determining the critical relationships of $S\lambda/K\lambda$.

It is hoped that these observations may serve to establish guidelines in the development of analytical methods designed to yield information relating to visual color perception as well as to the chemical and physical characteristics of food samples.

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The technical assistance of Mrs. Lisa Brinner and Mr. Joachim Wolf is gratefully acknowledged.

Paper presented in the Symposium "Colorimetry of Foods" at the 28th Annual Meeting of the Institute of Food Technologists in Philadelphia.

. . . *continued* . . .

Color □ Info PortFolio . . .

of the red color of tomato.

Irradiation of apples increases the yellowness of the fruit in storage.

Color Lab Grant for Lehigh University

Pennsylvania's science and engineering board has made available $165,000 to aid Lehigh U. in setting up a new color physics laboratory.

The laboratory will be under the direction of E. M. Allen, Lehigh U. research professor in chemistry.

Color Short Courses at Rensselaer

Two important subjects will be thoroughly explored in short courses this summer at the Rensselaer Polytechnic Institute.

"Principles of Color Technology" will be offered August 11–15, and "Advanced Color Measurement" will be given August 25–29.

Obtain further information from the Dean of Continuing Studies M. H. Jordan, R. P. I., Troy, N. Y. 12181.

German Color Abstracts

The journal *Die Farbe* has in the past included abstracts of articles on color that are well known for quality service in documenting the color field.

These abstracts (in German) are now available on separate file cards (approx. 4 × 6″) on either cardboard ($1.50 plus postage), thin paper ($1.50) or transparent paper ($2.10) in lots of 120 cards.

Subscriptions through The German Federal Board of Testing Materials, Div. 5.4: Color Metrics, Unter den Eichen 87, D-1000 Berlin 45.

Tintometer Booklets

Two interesting booklets containing lectures on color given by F. J. Heath are available from The Tintometer Limited, Salisbury, England. The titles: "Colour, how we see it and how it is measured" and "An introduction to the C.I.E. system." Costs: 3/6 and 5/ respectively.

A booklet listing in very concise form some 300 simplified colorimetric tests that can be performed with the new Lovibond 1000 comparator is available from Tintometer's USA representatives, Hayes G. Shimp Inc., Willis and Hampton Aves., Albertson, N. Y. 11507.

Acta Chromatica Regains Color

The Color Science Association of Japan, which ceased publishing their journal *Acta Chromatica* late in 1965, has resumed issuing the color magazine with No. 1 of Volume 5 dated October 1967.

The publication is primarily in English, and provides a means for color workers in the U.S.A. and elsewhere to be informed of color research going on in Japan.

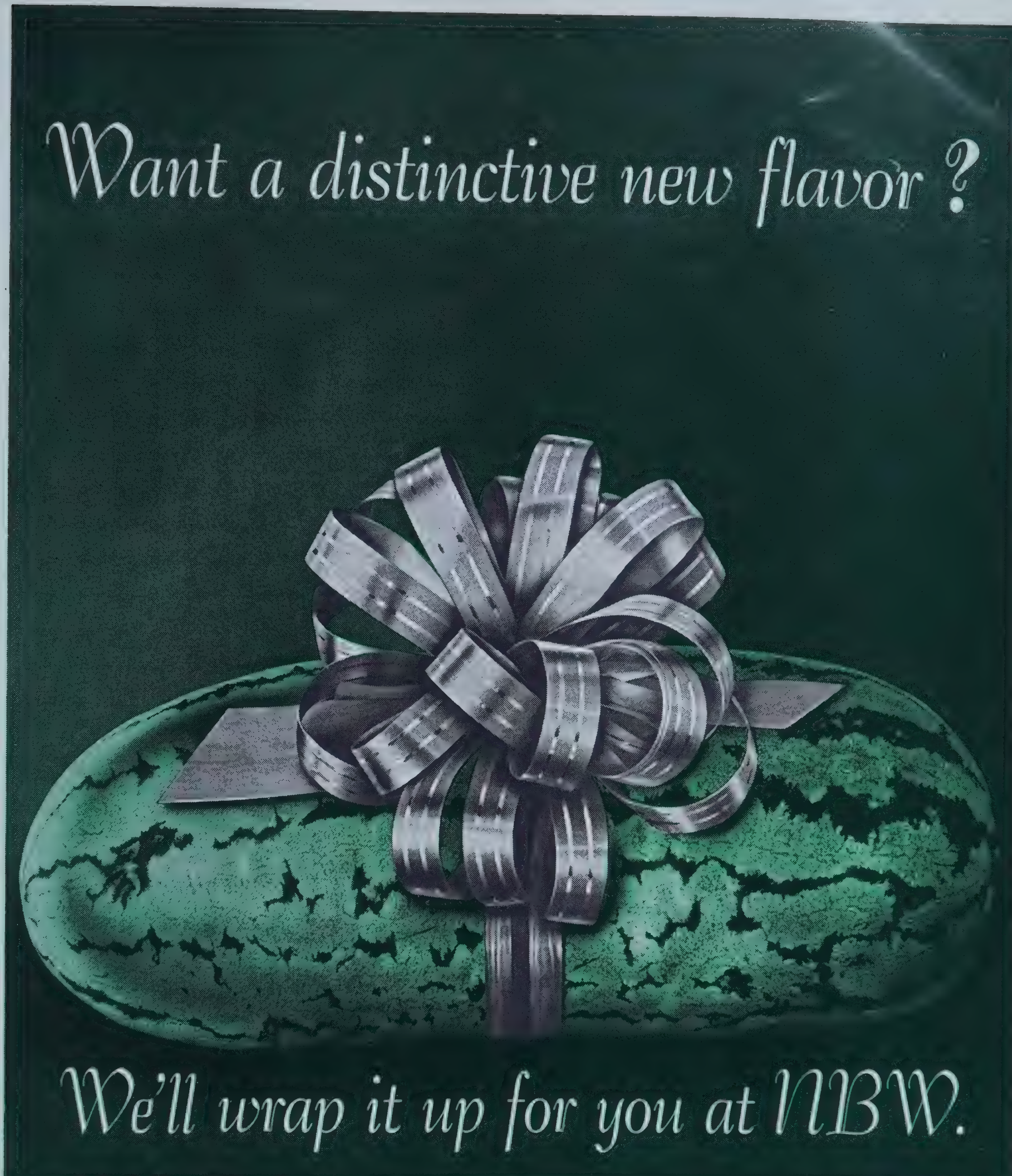
Annual subscription ($5 outside Japan) through Prof. H. Matsuo, c/o Dept. of Ophthalmology, Tokyo Med. College Hospital, 1-53 Kasiwagi, Shinjuku-ku, Tokyo, Japan.

Chromatic Strength —Some New Definitions

Two papers published in the *Journal of the Optical Society of America* are of interest to food color people: Chromatic strength of colors. I. Dominant wavelength and purity; and Part II, The Munsell System. Both are by R. M. Evans and B. K. Swenholt of Eastman Kodak Co., Rochester, N.Y. 14650.

The first paper describes a new visual threshold recognized lying between colors that appear to contain gray and those that appear fluorescent. The new function is an approx. constant multiple of the previously known purity threshold; it was determined from the dominant wavelength at high purity on a white (7000 K) background. The function is independent of purity and has been named the chromatic threshold.

The second paper gives an approximate model of the Munsell color space in terms of dominant wavelength and colorimetric purity. A single curve was found to describe the chromaticities in all Munsell Chroma circles, and this curve is identical with that describing the threshold between colors that appear to contain gray and those that appear to be fluorescent.


Want a distinctive new flavor ?
We'll wrap it up for you at NBW.

COLOR & TURBIDITY in SOLUTIONS

W. O. BERNHARDT

THE AUTHOR is research associate, Spreckles Sugar Co., Woodland, California.

☐ AN ACCURATE determination of the color of solutions is necessary in the control of quality of many food products.

Where the solution of the pure product is normally colorless, the presence of slight coloration is regarded as a measure of impurities. In the case of sugar solutions and syrups, acceptance of the product is often contingent on a specified maximum color.

Aqueous solutions of pure sucrose are brilliantly clear and water white. Solutions of granulated sugars may display a slight coloration and a slight haze, due to the presence of minute traces of impurities in the product.

Color and turbidity

The aim of color measurements in sugar solutions is the numerical expression of the degree of coloration. Since the coloration is very low, it would serve no useful purpose to express it in terms of tristimulus coordinates or related systems. The color is, therefore, expressed simply in terms of an absorption index at a specified wavelength.

When the solution also displays a slight haze, it is not possible to determine the absorption index through a single measurement since the haze also attenuates the transmitted light through scattering. The optical term for this scattering of light is turbidity. It is the result of differences in the refractive indices of the solution and the trace impurities suspended in the solution.

Rieger et al. (1959) investigated extensively the absorption and scattering of light by sugar solutions and showed the additive relationship of the indexes of absorption and scattering that account for the total attenuation index of the light.

The turbidity index can be found independently of absorption by measuring light scattered from the solution in all directions.

Total attenuation can be determined by measurement of the light transmitted by the colored and scattering solution.

Given these two indexes, the absorption index (the measure of light attenuation due to color) can be found as the difference between the total attenuation index and the scattering index.

Scatter error

In the determination of the attenuation index through transmittance measurements, serious errors may occur when some of the scattered light is permitted to enter the photo detector. Very large errors occur when the solution scatters light predominantly in a forward direction, toward the photo tube.

Forward scattering occurs in sugar solutions due to the presence of colloids and other suspended matter. The angular distribution of the light scattered by solutions of granulated sugar is best demonstrated when plotted in polar coordinates. Figure 1 shows a typical scattering envelope for solutions of granulated sugar.

The scattering envelope shows clearly that light is scattered mostly forward, in the direction of the incident beam, and is confined to a small angle. The errors resulting from the

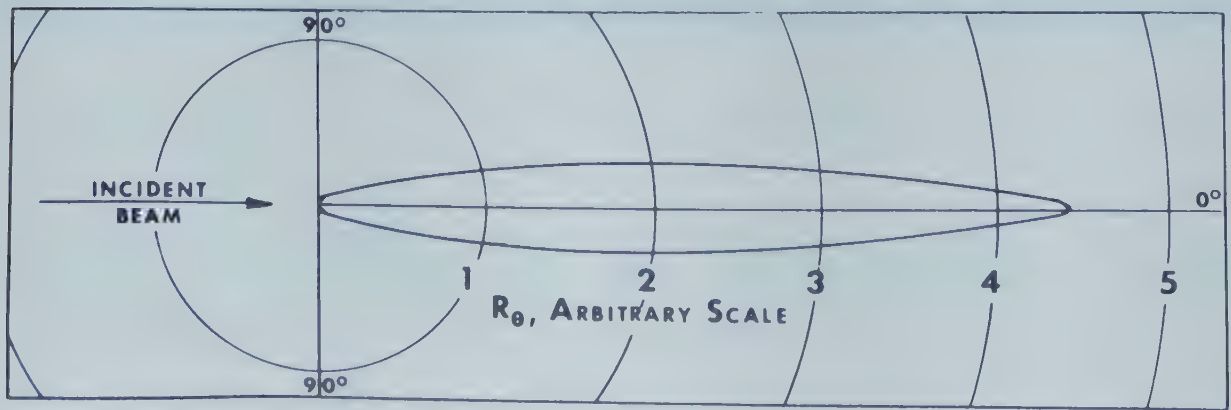


Figure 1—Scattering envelope for a solution of granulated sugar.

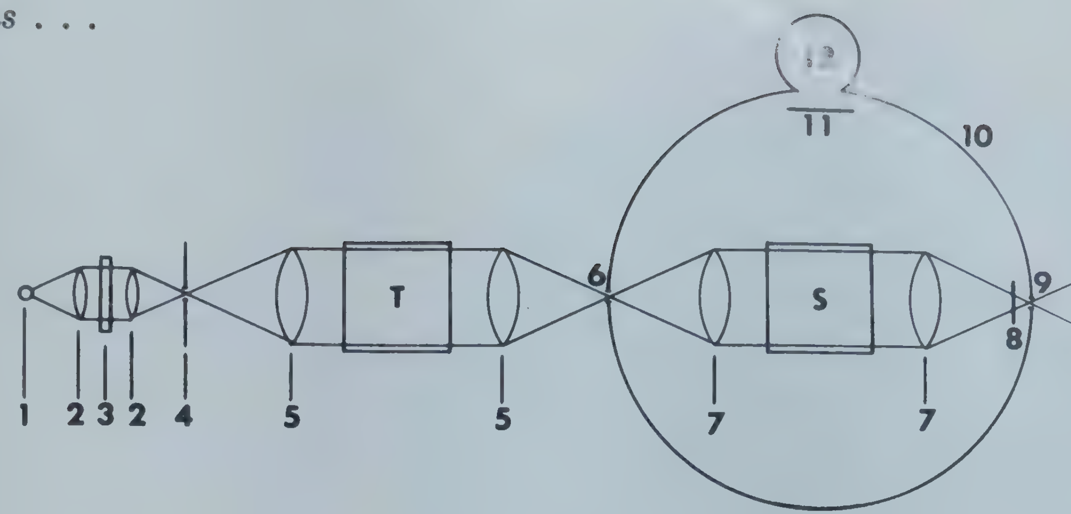


Figure 2—Sphere photometer optics (schematic). 1 ± 6.5V tungsten lamp; 2 = condensing lenses; 3 = interference filter, 420 nm; 4 = source aperture; 5 = collimating lenses; 6 = entrance aperture; 7 = collimating lenses; 8 = movable shutter; 9 = exit aperture; 10 = integrating sphere, white diffusely reflecting paint; 11 = baffle; 12 = phototube, located behind baffle.

inclusion of forward scattered light in the transmission measurement were determined on a Beckman DU spectrophotometer with a sugar solution having a normal level of turbidity, using 5 and 10 cm sample cells.

Table 1 shows that the errors are appreciable and that they are affected by the length of the sample cell. The errors are also a function of the total light scattered by the sample solution and of the geometry of the optical system employed in the measurements. It is thus not surprising that, in the presence of turbidity, the attenuation of a given sample may differ widely when determined on different photometers, even when of the same manufacturer.

The sugar industry, over the years, has proposed and evaluated a large number of methods for the determination of color in the presence of turbidity, utilizing available photometers. Only quite recently it was realized that the interaction of forward scattering by the solution with the optical geometry of the photometers was causing much of the divergence of analytical results inherent in these methods.

Integrating sphere photometer

Studies by the Research Group of Spreckles Sugar Company indicated clearly that the determination of the attenuation index of solutions in the presence of turbidity could not be made on available photometers without extensive modifications. The studies further indicated that a measurement of the total light scattered by the solution is necessary for an accurate determination of the scattering index. The Research Group therefore undertook the design of a photometer capable of performing these determinations. The specifications for the design included the following:

1) Exclusion of forward scattered light in the transmission measurement.
2) Integration of all scattered light by optical means.
3) Digital readout of transmission and scattering values to the third decimal place.
4) Rapid determination of color and turbidity indexes, as required in quality control.
5) Operation by relatively unskilled technicians.

The optical train of the instrument is shown schematically in Figure 2.

With this arrangement, light illuminating any part of the sphere interior is repeatedly reflected within the sphere before it reaches the phototube.

The sample cells used in the photometer are made from clear glass with optically flat windows to permit the measurement of transmitted light with the cell positioned between lenses (5), in the "T" position. The transmitted light enters the sphere through aperture (6)—effectively preventing illumination of the phototube by light scattered from the solution—and illuminates the surface of the shutter (8). After multiple reflections from the sphere interior, it reaches the phototube (12).

Thus, the quantity determined by the transmittance measurement represents the true attenuation, namely, the sum of the absorption and scattering indexes.

The light scattered by the solution is measured when the sample cell is positioned between lenses (7) inside the sphere and the shutter (8) is open. When the solution does not scatter light, the light entering through aperture (6) leaves the sphere through aperture (9). When the solution scatters light, the scattered light illuminates the sphere interior and, after multiple reflections from the sphere surface—which in effect integrates the scattered light—it reaches the phototube.

With one measurement giving the total attenuation and the other the amount of scatter, it becomes a matter of simple arithmetic to find the absorption index that represents the color in the solution, independent of mutual interferences.

While originally developed for the sugar industry, the photometer is suitable for use with many other solutions where the determination of coloration and turbidity is required.

The design and operation of the instrument was described in an earlier publication (Bernhardt et al., 1962). A commercial version of the photometer and its practical application are described in Bulletin SP366 available from the manufacturer, Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia Pa. 19140.

Table 1. Measurements on sugar solution of normal level of turbidity.

	10 cm Cell		5 cm Cell	
	% Transmittance	Atten. Index	% Transmittance	Atten. Index
Measured	75.5	20	86.8	20
Actual	69.9	25	84.3	24
Error	8%	20%	3%	17%

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Based on a paper presented in the symposium "Colorimetry of Foods" at the 28th Annual Meeting of the Institute of Food Technologists in Philadelphia.

4.

PIGMENT CONTENT and COLOR in FRUITS and VEGETABLES

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□ THERE HAS BEEN a natural desire to use colorimetric rather than chemical methods of pigment analysis ever since practical tristimulus colorimeters became commercially available.

There are logical reasons for this since tristimulus colorimetric measurements are usually much quicker and cheaper than the conventional chemical methods. Chemical methods in pigment chemistry often refer to a colorimetric endpoint and the literature is confusing in this aspect.

Nomenclature in modern chemical analysis uses the word "absorptimetric" rather than the obsolete "colorimetric" name for analyses involving light absorption at specified wavelengths. The old fashioned term "colorimetric" referred to the days when the analyst did match two colors in a visual colorimeter to determine the concentration of an unknown against a standard. This, of course, is still done, but the term "colorimetry" is no longer used in the chemical sense but is reserved for use in actual color measurement. In this paper "absorption" will be used for light absorption in chemical analysis and "colorimetry" for actual color measurement.

Sweet potatoes

One of the earlier attempts to replace a chemical analysis with a colorimetric one was in the determination of beta-carotene in sweet potatoes. Beta-carotene is important in this crop for two reasons. First, it is an important nutritional component as a precursor of vitamin A, and second, it contributes to a pleasant orange color. Plant breeders of sweet potatoes desire both aspects in addition to many others such as yield, disease resistance, etc. Chemical analyses for beta carotene are fairly involved and a program designed to test thousands of seedlings could be done much more quickly and economically if one could measure the color rather than the actual pigment.

Many workers have studied the relationship between pigment content and color of sweet potatoes (Ezell et al., 1952; 1952a; 1959; Kattan et al., 1957; Ahmed et al., 1962; Hernandez et al., 1965; Lauber et al., 1967). Some correlations of total carotenoids with color are listed in Table 1. In general, the content of total carotenoids correlated very well with tristimulus "a" or "L" or a combination of both. The "b" value as measured with a Gardner color meter did not correlate with chemical estimation of total pigment.

The earlier and lower correlations of pigment and color were attributed by Lauber to problems in sampling since one reading of a cut surface of a root was compared with carotenoid content of the whole root. A gradient in total pigment content from the proximal to the distal end of the root is known to exist (Ezell et al., 1959)

Table 1. Relationship between color and pigment content in sweet potatoes.

Author	Correlation Total carot. $\bar{c}$	r or R^2	Comments
Lauber (1967)	Gardner Rd	−0.918	One typical series (n = 20) range—pale yellow to orange
	Gardner a	0.916	
	Gardner Rd,a	0.928	
	Gardner Rd,a,b	0.942	
	Gardner a	0.920	Three series (n = 83)
Hernandez (1965)	Gardner L	−0.863	n = 1500 samples
	Gardner a,L	0.846	range—white to
	Gardner b,L	0.217	deep orange
	visual rating	0.790	
Ahmed (1962)	Gardner L	−0.903	n = 77
	Gardner a	0.957	range—white to
	Gardner L,a	0.960	deep orange
	Gardner L,a,b	0.960	
Ezell (1959)	Gardner Rd	−0.40	
	Gardner a	0.26	n = 90 (one variety)
	Gardner a/b	0.41	
	Rd,a,b	0.41	

and this introduces a sampling problem. Later workers compared the color with the pigment content close to the actual surface which was measured for color.

One would expect other sampling problems to influence the correlations such as moisture changes, pithy breakdown, texture changes—but these can be handled. Another factor in the higher correlations is the use of a wider range of samples as compared with one variety used by Ezell.

Theoretical considerations would decree that correlations of color and pigment involving, say, a storage study in which the major change was a synthesis of beta-carotene, should be very high.

Similarly, cultivars in which the major difference was beta-carotene should be equally high. This may not always be the case, however, since contrary to the usual situation, in which beta-carotene comprises 80–90% of the total carotenoid pigment, some may have as little as 22% (Ezell, 1952a). The remainder of the carotenoid pigment content may be quite varied and one would not expect, say, xanthopyll to have the same tintorial value as beta-carotene.

In order to arrive at a high correlation between color and pigment content with varieties that differ in type as well as quantity of carotenoids, each pigment would have to be weighted for its contribution to the color.

However, in spite of the above problem, the correlations between total carotenoids and color are sufficiently high for predictive purposes.

For color appearance alone, it would not matter which pigments are present if they were all equally stable.

For nutritional predictions, one should check the color values against a chemical method to make sure that the increase in color is actually due to precursors of vitamin A.

Hernandez (1965) pointed out that the color readings were a more accurate index of total carotenoid content than the visual estimates of color. Lauber pointed out that most of the variations in the correlations of color and pigment content were due to the chemical analysis. In other words, the color values were more accurate than the chemical analyses.

Hoover et al. (1961) used a tristimulus colorimeter to evaluate the carotenoid content and acceptability of a series of sweet potato puree blends. The carotenoid content correlated very well with Gardner a and b and the Rd value contributed very little in contrast to the situation with roots (Table 2).

The correlations of visual score with carotenoid contents were low indicating that the instrument could do a better job of predicting pigment content. One of the reasons for the low correlations of carotenoid content with visual score and also with Rd values was the discoloration effect which tended to mask the pigment content. Another reason may be that the analytical method measured only beta-carotene whereas visual judgments would also take into account the other carotenoids. Of course, the tristimulus methods would also measure the color contribution of the other carotenoids.

Table 2. Relationship between color and pigment content for sweet potato purees.

Correlation	r or R^2	Comments
Visual vs Gardner a	0.885	24 samples from 5 varieties.
Visual vs Gardner a,Rd	0.887	Canned, blended pulp.
Visual vs Gardner a,b	0.894	
Visual vs Gardner Rd,a,b	0.898	
Beta-carotene vs Gardner a	0.914	
Beta-carotene vs Gardner a,Rd	0.931	
Beta-carotene vs Gardner a,b	0.942	
Beta-carotene vs Gardner Rd,a,b	0.942	
Visual vs hue	−0.827	Munsell hue, value and chroma
Visual vs hue, value	0.844	calculated from Gardner values.
Visual vs hue, chroma	0.870	
Visual vs hue, value, chroma	0.872	
Beta-carotene vs visual score	0.662	

Table 3. Relationship (r or R^2) between pigment content and color for squash.

Correlation Total carot. with Gardner	Variety			
	Butternut	Redskin	Golden Delicious	All 10 varieties
Rd	0	−0.54	−0.75	0.85
a	0.14	0.54	0.83	0.86
Rd,a,b	0.48	0.64	0.56	0.81

Table 4. Correlation coefficients between surface color and pigment content for fresh cranberries.

Correlation	Correlation coefficient	
	Early Black (44 samples)	Howes (20 samples)
Agtron × pigment content	−0.645	−0.793
Agtron × Colormaster R	0.880	0.946
Agtron × absorption ratio	−0.849	−0.701
Pigment content × absorption ratio	0.934	0.897
Log Agtron vs log pigment content (19 uniformly colored samples from both varieties)	0.961	

Squash

Francis (1962) studied the relationship between carotenoid content and instrumental readings on 10 varieties of squash (Table 3).

In general, the Gardner "Rd" and "a" values correlated most highly with the total carotenoid values but the correlations were lower than for sweet potatoes. Within one variety the correlations (total carotenoids vs Rd) ranged from zero for Butternut with a low spread of carotenoid content to a high of 0.77 for Mammoth Potiron with a wide spread of pigment content. The correlations for all varieties combined were higher (Table 3) probably because the range of values was greater. The correlations between color and carotenoid content of squash are likely to be lower than with sweet potatoes because beta-carotene usually is lower in proportion to the rest of the carotenoids (25–35% in Butternut squash; Lewis, 1962).

Cranberry products

Color measurement in cranberry products is another good example of the interrelation between color and pigment. The two main products manufactured from cranberries, juice and sauce, derive much of their popularity from their appealing red color and the tart taste. Cranberry juice, in particular, known in the trade as cranberry cocktail, has had a very rapid increase in sales in recent years.

The color of cranberry juice cocktail is due primarily to four red anthocyanin pigments: cyanidin-3-arabinoside, peonidin-3-arabinoside, cyanidin-3-galactoside and peonidin-3-galactoside. There are a number of other minor red pigments as well as six yellow flavonoid pigments, but they are minor contributors to color.

The rapid increase in demand for berries for cocktail has required larger supplies of well colored berries. In normal production the berries may be white, pink, light red or deep red depending on a number of horticultural practices, climatic conditions, degree of shading, etc. Obviously, there is an economic incentive to produce berries with higher pigment content.

The industry desires to pay growers on the basis of general quality, color and keeping quality. Yet in order to do this successfully, adequate objective tests for each attribute are very desirable. Tests for general quality are based now on subjective evaluation plus a knowledge of past performance. Tests for color are more highly developed.

It is obvious that there should be a relationship between color and pigment content. In the processed product, in which pigment is distributed homogeneously, the relationship is more obvious. In the fresh fruit, in which the pigment is localized in the cell layers immediately below the epidermis, the relationship may be less obvious.

However, in view of the fact that color measurements on fresh fruit could probably be made much more quickly and cheaply than chemical measurements of pigment content the economic incentive to develop a colorimetric method is obvious.

Good chemical methods of estimating anthocyanin content of cranberries and cranberry products were developed some years ago (Francis, 1957). Recently good quantitative methods of analysis for individual pigments have been developed (Fuleki et al., 1968).

The chemical methods were quite adequate to study the effects of horticultural practices such as effect of spray and fertilizer schedules, pigment development after harvest, etc. Colorimetric methods using conventional tristimulus colorimeters were developed to measure surface color of the fresh berries and processed products (Francis et al., 1963). Another approach used an instrument developed for tomato grading, the Agtron, modified to take a larger sample (Francis, 1964).

Previous research on the relationship between surface color of fruit and color of product had established correlations of approximately 0.8 (Table 4). This work was based on blends prepared by mixing different proportions of red berries with light pink ones. This approach seemed encouraging and was extended to cover the range of fresh fruit found in practice (Francis, 1964). The Agtron H used in this work had an 8 inch diameter sample holder and measured both red and green reflectance. In practice the red reading was adjusted to read 50 and the green reflectance was measured. The Agtron readings referred to in Figure 1 are the green reflectances.

The correlations in Table 4 between Agtron reading and pigment content are too low for prediction purposes. The correlation between the Agtron and a tristimulus colorimeter, the Colormaster Differential Colorimeter, were quite high indicating that the Agtron was measuring color. The two indices of pigment content also correlated highly indicating that the chemical methods were probably adequate.

The above data were obtained with "field-run" samples of two varieties. When samples were actually hand sorted to obtain uniformly colored samples, the reasons for the low correlation between surface color and

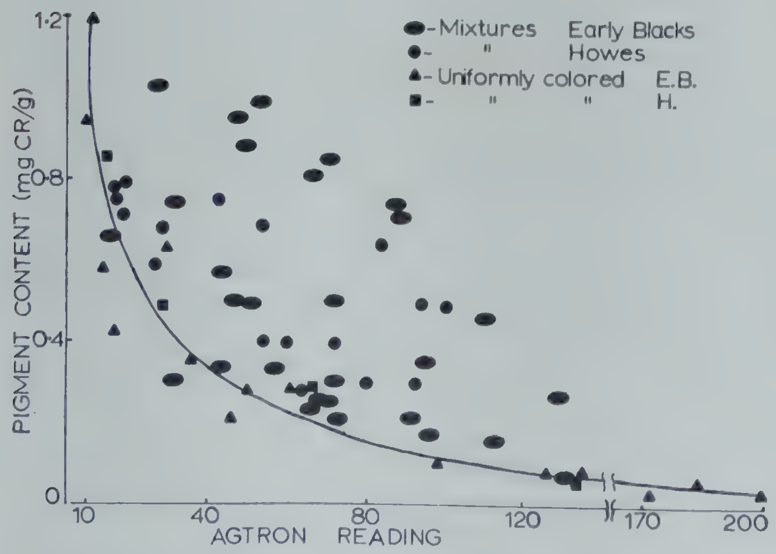

Figure 1—Plot of Agtron G reading against pigment content for fresh cranberries. The triangles and squares refer to uniformly colored berries. The circles and ellipses refer to mixtures of well-colored and pale berries.

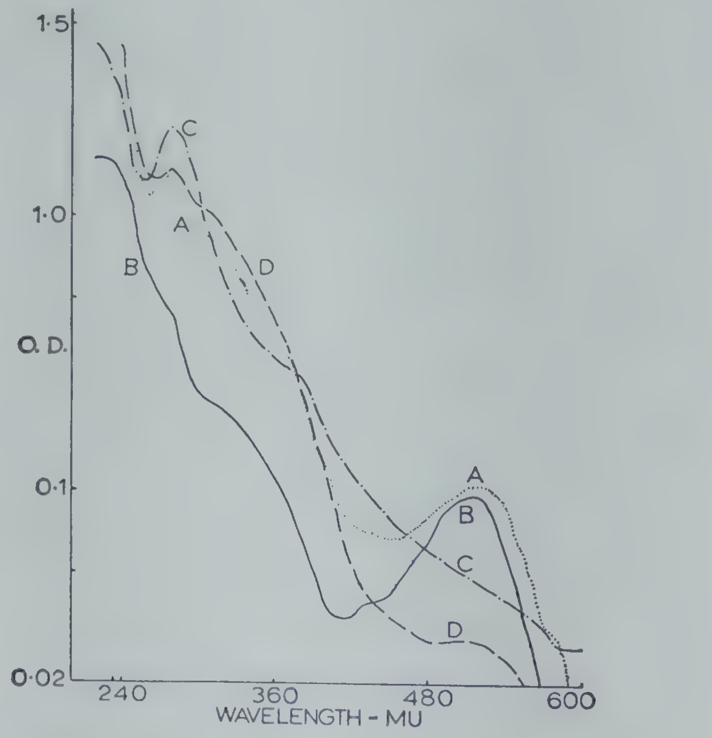

Figure 2—Plot of log optical density vs wavelength for cranberry cocktail. Curve A refers to cocktail prepared from well colored berries and stored at 38°F for one year. Curve B was fresh cocktail prepared from well colored berries. Curve C refers to cocktail from well colored berries, and stored at 100°F for one year. Curve D refers to cocktail prepared from pale berries and stored at 38°F for one year.

pigment became obvious. A plot of log Agtron reading against pigment content for the uniformly colored samples showed a correlation of 0.961. The data are plotted in Figure 1. The relationship is log log in nature because a small amount of pigment in a very dark berry would have no effect on surface color, whereas the same amount of pigment in a very pale berry would have a very large influence on surface color.

It is possible to have a mixture of berries with the same overall surface color but with very different pigment contents. For example, a mixture of 70% dark red berries with 30% white could have the same overall color as a mixture of 80% medium red and 20% white berries yet the pigment contents could be 0.81 and 0.23 mg C.R./g respectively.

The above reasoning demonstrates a practical problem in attempting to substitute a simple surface color measurement for a chemical analysis. A surface color measurement would serve very well on the low pigment side of the graph to determine an adequate degree of pigment development for acceptance of berries, but would be inadequate for allocation of berries for processing.

Since the pigment in the processed product is distributed uniformly, it is more accurate to determine the total pigment in the fresh berries as a means of allocating berries for processing. The basic problem in substituting a color measurement for a chemical analysis in this case is that the pigment is not distributed homogeneously throughout the product.

Cranberry juice cocktail

It is possible to measure the color of a clear colored liquid with homogeneous pigment distribution fairly easily with a conventional tristimulus colorimeter equipped with a transmission attachment. Three two-dimensional plots of say, L vs, a, L vs b, and a vs b would serve to delineate the volume of the solid which would contain the range of colors found in a particular product.

Volumes within the solid could be used to determine acceptable limits for a given grade of product. This approach is very similar to that used to define color tolerances using reflection tristimulus colorimetry on packaging materials (Francis, 1968). With liquids and transmission tristimulus colorimetry this can be done very accurately but it does require three plots.

It may be possible to use short chemical methods or a combination of a chemical method and a colorimetric method to define acceptable quality in one graph. One of the short chemical methods is the ratio of absorption at a wavelength of maximum absorption for a pigment to the absorption at another point in which the pigment does not absorb in order to correct for turbidity or other effects. Such a ratio is illustrated in Figure 2 and would be 515/415 nm for fresh cranberry juice.

This is a very simple measurement and probably is adequate as an index of pigment content, and hence, color of fresh juice. It is inadequate to predict color when considerable pigment degradation has taken place on storage. In this situation, another parameter has to be added and a plot of the ratio vs hue, as obtained with a tristimulus colorimeter (Fig. 3) could be used to indicate acceptable color. However, if one has to use a tristimulus colorimeter in any event to get data for this plot, it might be safer to plot tristimulus transmission data directly in one or more graphs.

Absorption ratios have been used with other products such as berry concentrates (Ponting et al., 1960) and wines (Robinson et al., 1966). The concept has been developed with good success for turbid materials (Birth et al., 1965) both for colorimetry and more important, determination of internal quality by non-destructive methods. The ratio technique, using

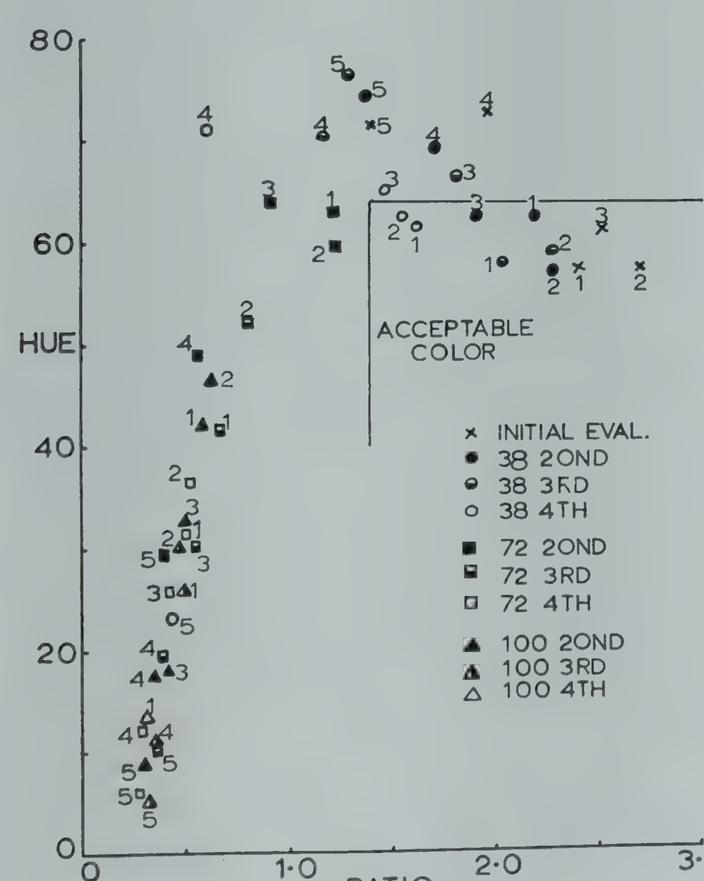

Figure 3—Plot of hue against absorption ratio at 515/415 nm for cranberry cocktail. The figures beside the points represent respectively the cocktail prepared from 100% red (R), 75% R and 25% white (W), 50 R and 50 W, 25 R and 75 W, and 100 W blends of berries. The 2nd, 3rd, and 4th evaluations were made at 4, 8, and 12 months at 38, 72, and 100°F storage.

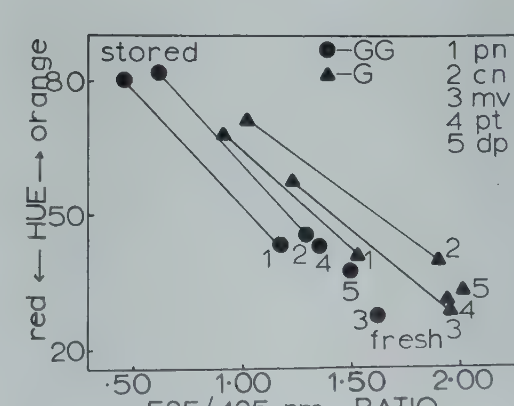

Figure 4—Plot of hue against absorption ratio for wines containing different pigments. The figure beside the point refers to the aglycone with a circle indicating a diglucoside and a triangle representing a monoglucoside. The change from fresh to stored refers to storage of the wines at 120°F for three weeks.

equipment pioneered by Birth and Norris has recently been suggested for on-stream color control of cranberry juice (Staples et al., 1968). This area—termed "wide range spectrophotometry," using absorption ratios measured over several optical density ranges—is very promising for future development.

Wines

Colorimetry of wines is another area in which the color and pigment relationship is important.

A considerable portion of the "mystique" involved in merchandising wine is concerned with appearance. Transmission spectrophotometry has been used for interpreting wine color in several papers from California (Ough et al., 1962; 1968).

Robinson and co-workers (1966) used a sphere attachment for a Hunter Color Difference Meter to measure the color of New York State wines. This is apparently a straightforward and successful application of conventional tristimulus transmission colorimetry and could be used to follow dilution, degradation of pigments, heat effects, browning, effects of sulfite, etc. They were studying the relationships between type of pigment and color in wines and made the interesting discovery that some of the anthocyanin mono- and diglucosides formed pairs of optical metamers (Fig. 4).

In one case, wines colored with peonidin and cyanidin monoglucoside and peonidin and petunidin diglucoside all had the same hue but the absorption ratio 525/425 nm varied from 1.18 to 1.91.

This points out the unreliability of the absorption index as a predictor of color when materials of different pigment composition are involved.

Joslyn et al. (1967) investigated the relationship between type and concentration of phenolics to the color and stability of Rosé wines. They used conventional chemical tests for total phenolics, flavonols, leucoanthocyanidins and anthocyanins.

Color evaluations were done by conventional transmission spectrophotometry and tristimulus colorimetry as well as by a new rapid thin-layer colorimetry method. This method, using a 4 mm thick cell and a white background, was very effective for characterization of color of wines. Furthermore, when the chromaticity coordinates x and y were calculated and transformed to dominant wavelength and purity, the sequence of events in storage could be followed. The change in dominant wavelength is a good indication of anthocyanin and flavonol degradation, and the increase in purity is an indication of the extent of browning.

Kubelka-Munk equations

Future research on the relationships between pigment content and color for turbid media is likely to be focussed on the application of the Kubelka-Munk equations. Space does not permit an adequate description of this concept in this paper but it has been discussed by Little and coworkers (1964, 1967).

It should be possible to obtain data from a conventional colorimeter or spectrophotometer, interpret it in terms of the K.-M. equations and provide a relatively simple and accurate color evaluation method for a number of food applications.

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Paper presented in the Symposium "Colorimetry of Foods" at the 28th Annual Meeting of the Institute of Food Technologists in Philadelphia.

Use of Certified FD&C Colors in Foods—Addendum

THE article published in *Food Technology* August 1968, pp. 16–19, gave color concentration levels in various processed foods along with total sales to various industries. Calculated data show total color ingested per capita per day to be far below the daily intake considered acceptable by FAO/WHO for each of the 3 major-use FD&C colors.

The article was based on a study supported by the Certified Color Industry Committee, comprising Allied Chemical Corp.; Crompton & Knowles, Althouse Div.; The Hilton Davis Chemical Co.; H. Kohnstamm & Co., Inc.; Stange Co.; and Warner Jenkinson Mfg. Co.

LETTERS

"Food Technology's" Likable Form!

☐ I have a habit of writing letters to editors about matters of format that I don't like in scientific or technical journals to which I subscribe. For once, I want to congratulate someone about the matters of form that I find very much to my liking. I am grateful that in "Food Technology":

(1) References to the literature give the titles of papers and are otherwise rather complete. What a nuisance it is not to know, really, what a paper is about or at least to have some inkling of the field in which the authors are working! And what a small amount of space is saved by omitting the title and the address of the publisher, in the case of a book or pamphlet!

(2) Parts of different articles important to me only rarely appear on opposite sides of the same sheet. Usually if the last page of a non-scientific article is on an odd numbered page there is an advertisement on the other side. So it is not necessary, if I want to remove both articles for filing in appropriate but different places to get one of them Xeroxed. Xeroxing doesn't take long, but it is a nuisance in a case of this sort. In this connection, having the name of the journal and the issue printed on the bottom of each page is very helpful.

(3) I like having the summaries, the authors' names, and positions indicated on the first page of scientific articles.

(4) I like very much the fact that "Food Technology" presents such a variety of materials, original research papers, reviews, editorials, notices of patents, notices and reviews of meetings, notes on personnel and changes in personnel, etc.

(5) I like the colored advertisements, many of which, it seems to me, are the products of some of the finest color photography, commercial painting, and color printing in the world. I also like the binding with durable, but not rigid adhesive, and with no wire staples.

John D. Hartman
Cornell University

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Final dues notices will be mailed in February—Don't wait! People who receive a final notice are not mailed a March issue of *Food Technology*!

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Krafen will bring out the flavor of your foods because it has an abundance of lactose, a natural enhancer of flavor. The absence of casein (found in other dairy solids) means that sauces and gravies don't break down or "weep" when stored frozen, or at steam table temperatures. The whey proteins in Krafen help keep doughs more tender and moist, too, extending the shelf life of your product. Krafen also helps to produce more tender pie crust and pizza dough without extra shortening.

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Add Krafen to your instant potatoes an
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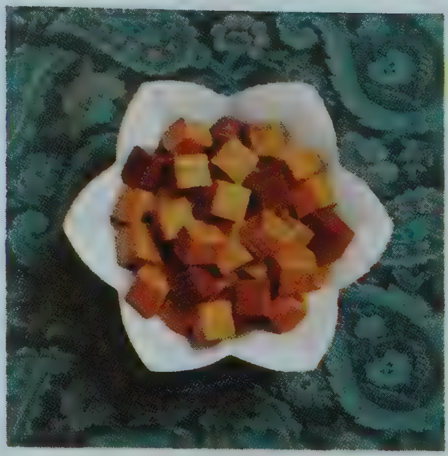
Brings out all the natural flavor of frozen casserole dishes, like beef stroganoff, and adds a tempting smoothness to the sauce.



Extends the flavor, volume and shelf life of confections like caramels and fudges.

Helps give hot roll mixes their delicious looking golden brown coloring.

Makes the breading on frozen fish sticks, fillets and shrimp come up golden brown and beautiful.

Improves the flavor and texture of frozen meat pies and gives crusts a melt-in-your-mouth flakiness.

Brings out all the natural flavor of dry soup mixes—chicken, mushroom, or celery—while adding body to the stock.

Makes pie fillings, like this pumpkin, smoother and more appetizing . . . and gives crusts a golden color and tender flakiness.

Gravy mixes come up smoother, with a better mouth feel, and gives the batter on frozen onion rings its rich, golden brown color.

Krafen keeps the cake tender and moist while giving the ice cream its smooth, velvety texture in this ice cream cake roll.

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FOOD PROFESSIONALS

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Report from Stockholm . . .

Symposium on the Evaluation Of New Protein Products

□ AT A SYMPOSIUM in Stockholm, sponsored by Wenner-Gren Foundation and the International Biological Program, 125 food scientists and physicians gathered to discuss methods for determining the nutritional value of new protein foods. A general conclusion from the conference was that the ultimate value of new protein foods is determined by their effectiveness in alleviating the symptoms of protein-calorie malnutrition.

• From the United States, Dr. Bernard L. Oser delivered a paper stressing that long-term animal studies should precede the introduction of new protein foods into the human diet. Speakers from other countries discussed the major categories of protein foods presently being introduced; oilseed and leaf proteins, fish protein concentrate, and single cell proteins derived by fermentation.

• Those in attendance generally agreed that world protein requirements for the next decade would be met by fortification of low-protein cereals with essential amino acids, by genetic improvement of corn and other grains, by increased production of animal (including marine) sources of food, by imitation of extended milk foods, and by new protein beverages. Textured protein foods and microbially derived products were projected for the longer range future.

• The symposium ended with the adoption of a resolution summarized as follows:

Despite recent developments, the world food situation remains precarious. The world distribution of protein will depend on government action as well as action by scientists.

Funds should be raised to permit re-evaluation of present protein distribution schemes, and governments should provide incentives for industry and research organizations (particularly universities) to develop new foods for underdeveloped countries.

Where feasible, protein foods should be developed from sources locally available in a given area.

Extensive and versatile testing facilities should be established to improve the entire pattern of national diets. Improved methods, with an emphasis on speed and simplicity are needed.

BERNARD L. OSER

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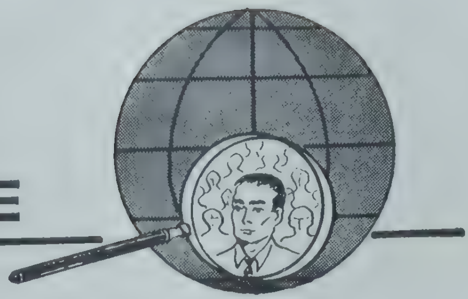
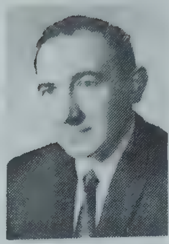
PEOPLE

ARE . . . .




COPLEY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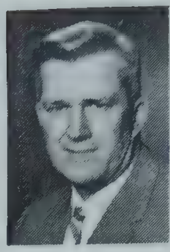

TUOMY


BELLISIME

■ **Dr. Michael J. Copley,** director of USDA Lab in Albany, Calif., retires after 21 years of service. . . . ■ **Dr. Morton S. Cole** appointed director of research at Paniplus Co., Kansas City, Mo. . . . ■ **Justin M. Tuomy,** U.S. Army Natick Labs, receives Army Research and Development award for new process to improve Army's food packet. . . . ■ **Lloyd Bellisime** heads West Coast operations for Gentry Corp. in Calif.

■ **Dr. Arthur Farrall,** recently retired from Michigan State University, has accepted a four month assignment at Punjab Agriculture University, Ludhiana, India, as a consultant in the Ford Foundation-Ohio State University project, to assist in the development of a teaching and research program in engineering for the dairy and food industries. . . . ■ **Leonard Allen** appointed special assistant to vice-president and director of national sales at Felton International, New York City. . . . ■ **Dr. Ernst T. Theimer** named chief scientific officer at International Flavors & Fragrances, New York City.

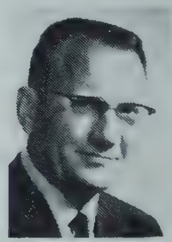
■ **David V. Koski** joins Du Pont Company, Wilmington, Del., as a technical representative. . . . ■ **George O. Hall,** technical consultant at Calgon, Pittsburgh, honored by American Meat Institute for 25 years' service to the industry through his discovery of Curafos. . . . ■ **Dr. O. Garth Fitzhugh** cited for his studies on chronic experimental toxicology and their application to determine safe levels of pesticides and additives in foods.

■ At A. E. Staley Research Center, Decatur, Ill., **Dr. Richard R. Hahn** heads new product development group, and **Michael W. Kossoy** named director of new technical service group. . . . ■ **Mrs. E. Roxie Howlett** appointed general manager of Howlett & Gaines, Inc., San Francisco. . . . ■ **Emory T. Payne** promoted to plant manager of Drew Foods, St. Louis, Mo.


HAHN


KOSSOY


HOWLETT


PAYNE

■ At International Flavors & Fragrances, New York City, **Dr. Simpey Kuramoto** appointed director of flavor application, and **Paul M. Cormack** named account manager. . . . ■ **Roy E. Martin** is general manager, vegetable protein products department at Swift Chemical Co., Chicago. . . . ■ **Dr. William L. Brown** appointed consultant to Lykes Food Products, Inc., Tampa, Florida.


KURAMOTO


CORMACK


MARTIN


BROWN

IN MEMORIAM . . . . ■ **Dr. David Levowitz,** *Professional Member of IFT and director, New Jersey Dairy Laboratories; at New Brunswick, N. J.* . . . ■ **Maurice A. Rice,** *Professional Member of IFT and technical director, new product development, North Star Dairy; at St. Paul, Minn.* . . . ■ **Dr. Sandy Trout,** *director of food preservation research branch, Queensland Dept. of Primary Industries; at Brisbane, Australia.* . . . ■ **Lawrence W. Siempelkamp,** *Member of IFT and sales representative for H. Kohnstamm; at St. Louis, Mo.*

Measurement of

Volatiles Transferred from

Plastic Packaging Films to Foods

ROBERT A. WILKS JR. & SEYMOUR G. GILBERT

☐ IN THE LAST two years, considerable work has been done in our laboratory on quantifying our hot jar method (Gilbert et al., 1965) for measuring residual solvents in packaging materials.

This work has led to development of a leakproof system for quantitative estimation of solvents in the jar headspace (Wilks et al., 1968).

Residual solvent analysis indicates only the potential for solvent transfer. Nevertheless, the ability to estimate residual solvents quantitatively is a prerequisite for a more important aspect of the problem: the relationship between residual solvent levels in films and flavor changes produced in foods contacting these films.

The effects of solvent transfer on food flavor previously have been investigated only by sensory testing. Such tests are time consuming and of limited precision. Hence, an objective method for determining residual solvent-food interactions would be a valuable tool in packaging technology.

an objective method requires . . .

An objective method must meet at least two requirements:

1. Determination of solvents in foods, from below threshold to rejection levels, must be quantitative.
2. Objective solvent measurements and organoleptic responses on the same samples must show good correlation.

This report is concerned with ascertaining satisfactory correlations. Therefore, attention was focused on the selection of:

1. Foods to which solvents transfer readily.
2. Packaging films sufficiently high in solvent content to permit ready transfer.
3. Means to measure the solvent content of foods.

. . . foods . . .

Because of the relatively high solubility of organic solvents in lipids, foods of high fat content were chosen. American cheese and cottonseed oil were used in this work as examples respectively of solid and liquid foods. Both have bland flavors, an added advantage in procedures involving sensory evaluation.

. . . films & solvents . . .

From studies of the efficiency of drying tunnels, a PVDC [poly(vinylidene-chloride)] coated cellophane-polypropylene laminate was available with a wide range of residual solvent levels. Since toluene was the adhesive solvent in this group of films, work to date is concerned with toluene transfer.

From the range of solvent contents, a film containing toluene at a level of approximately 90 mg/m^2 was selected. While this content is higher than levels in commercial films (1–10 mg/m^2), it allowed the rapid transfer necessary to test the applicability of methods. Tests on commercial films are now in progress.

. . . and a method.

The hot jar method of Wilks et al. (1968) was used to follow the transfer of solvents to foods. Its application was straightforward on American cheese, and it was ultimately employed also in tests on the cottonseed oil.

The method consists of a leakproof jar-and-lid apparatus in which a sample is subjected to a heating cycle to vaporize the volatile compounds in the sample.

The time and temperature parameters of the heating cycle are selected to assure maximum vaporization of the volatiles.

At the end of the heating cycle, an aliquot of the vapor-enriched headspace is removed using a hypodermic needle and analyzed by gas chromatography (GC). The GC peaks resulting from the volatiles of interest, e.g., residual or transferred solvents, are then quantified by comparing the aliquot peak area (as measured by the peak height × width at half height) to a standard curve.

For the work reported here, the standard curve was constructed by plotting the GC peak area for toluene versus the concentration of toluene in a series of toluene-hexane solutions.

Measurement of the peak of the aliquot enables quantitation of the concentration of toluene in the jar headspace.

The ideal gas law was demonstrated to hold for the system, i.e., the aliquot volume to the total headspace volume is independent of the temperature or the final pressure of the system. The concentration of toluene in the headspace can then be correlated to the concentration of toluene in the sample and thus to the amount of toluene which has transferred to the sample during the storage period.

The headspace analysis apparatus is pictured in Figure 1.

Gas chromatographic conditions: An F & M Model 810 equipped with dual

THE AUTHORS: R. A. Wilks Jr. is research assistant and S. G. Gilbert is professor of food packaging in the Department of Food Science, Rutgers University, New Brunswick, N.J. 08903.

Paper of the Journal Series, New Jersey Agricultural Experiment Station at Rutgers University.

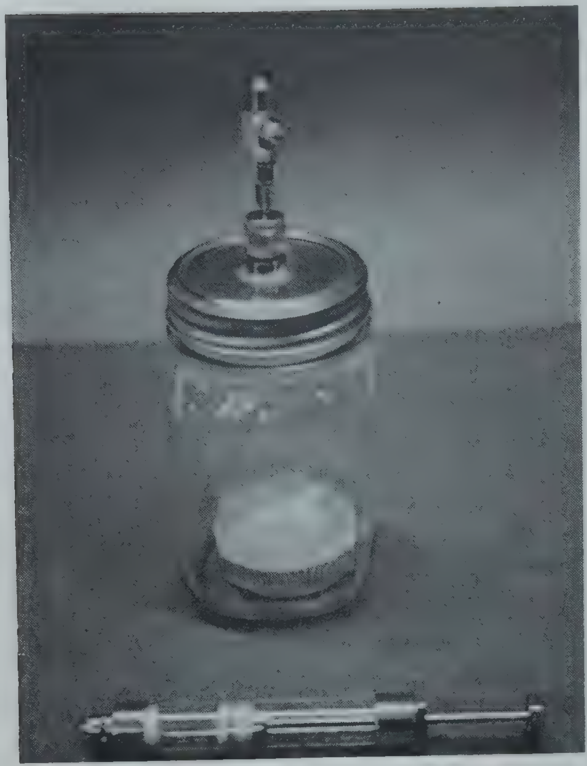


FIG. 1—*Mason jar with sample, showing evacuating and sampling assembly. Sampling hypodermic needle in the foreground.*

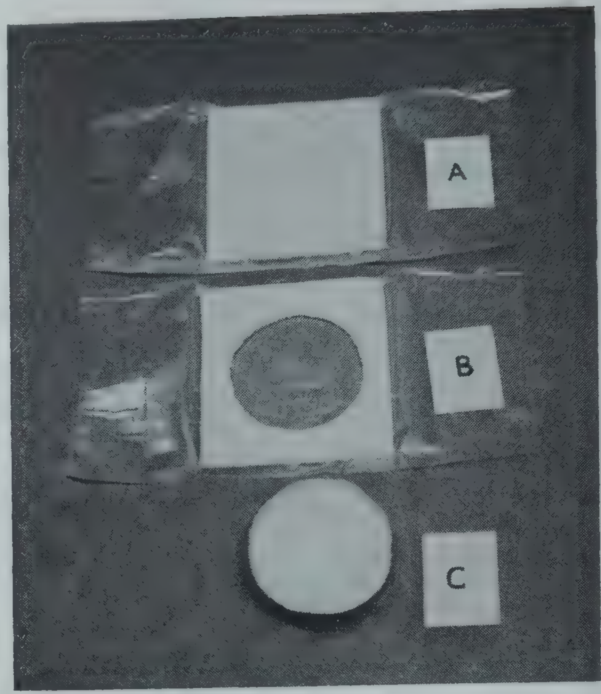


FIG. 2—*Sampling operation. A = intact slice of cheese. B = slice of cheese after removal of center portion by cutting with aluminum weighing dish C. C = the weighing dish containing cheese sample removed from slice.*

flame ionization detectors was used.

Injection Port: 250°C.

Column: 6′ × ¼″ aluminum tube packed with 10% OV-17 on Anakrom ABS 70/80 mesh. OV-17 is a 50% phenyl substituted dimethyl polysiloxane polymer, which exhibits slightly polar characteristics and has a high thermal stability.

Detector: 240°C.

Column Temperature: 70°C programmed at 10°C/min to 200°C.

Carrier Gas: 75 ml helium/min.

Sample: 5 ml headspace gas from 500 ml jar.

the results on cheese . . .

In the cheese study the first problem encountered was storage of the contact with the film. This was solved by using slices of American cheese which were wrapped individually with a coated cellophane.

Each slice was partially unwrapped, a 3-inch square of film was placed in contact with the cheese, and the wrapper was replaced. Entrapped air bubbles were avoided by carefully squeezing the bubbles to the sides with a straight-edge. All samples were then stored at 5°C.

At the end of the storage period, the slice was unwrapped and a sample was taken using an aluminum weighing dish as a cutter (Fig. 2).

In this way a 4.4 square inch

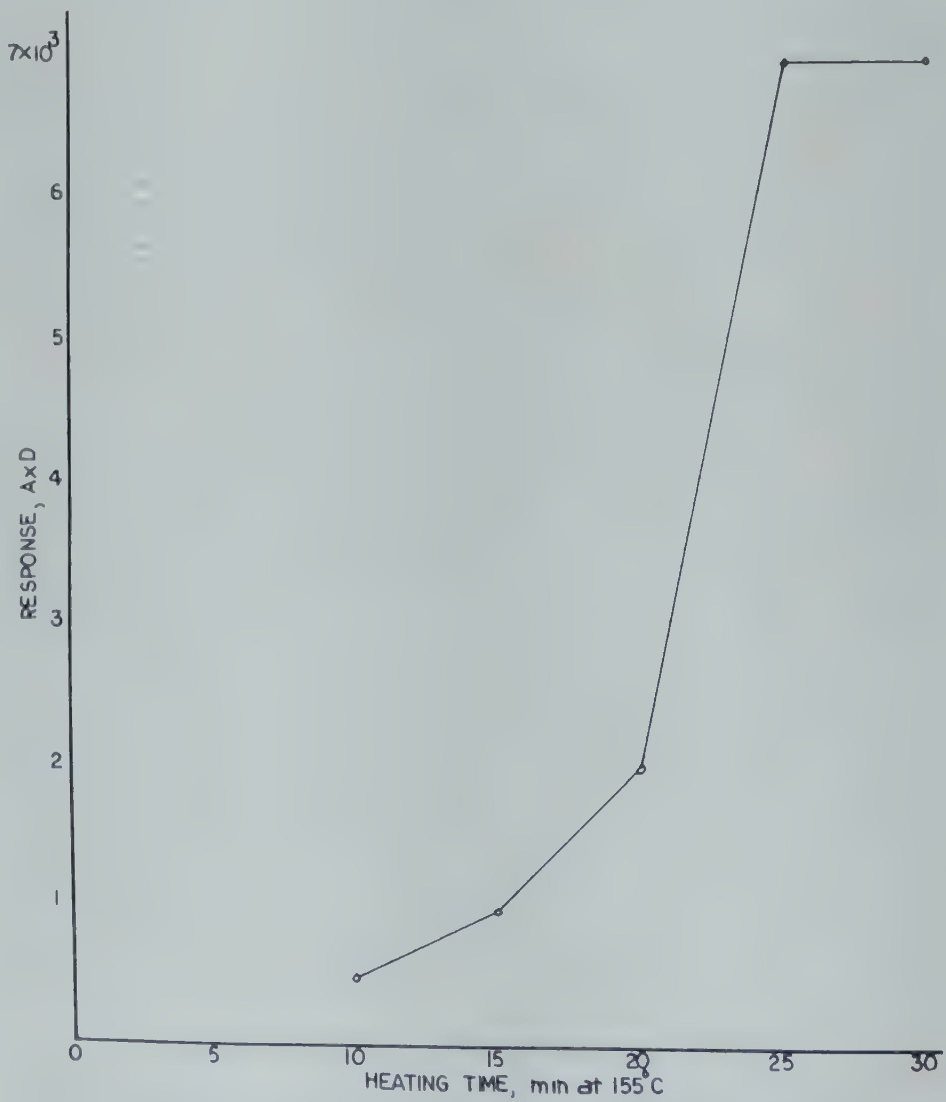


FIG. 3—*Effect of heating time at 155°C on toluene peak size on gas chromatograms of headspace gas over cheese.*

If your antioxidant doesn't "carry through" FORGET IT!

Sustane® BHA protects shelf life, and shelf life begins where processing ends. Thus, it's not enough to simply add an antioxidant. The antioxidant must protect your products *effectively,* long after processing.

But there are limitations on the amount of antioxidant which may be added to a product. And the manufacture of many food products calls for high temperatures that can destroy ordinary antioxidants in the processing plant, even before products reach the shelf. Sustane BHA, which is thermally and chemically stable and compatible with other ingredients, is able to withstand many difficult processing procedures and still provide excellent shelf life protection.

Since different food products present different problems, UOP Chemical Division has developed a variety of Sustane formulations to overcome the effects of rancidity...to preserve flavor, odor and quality. Sustane in various formulations and combinations of ingredients is available in flakes, for rapid solubility...in tablets, for convenience in handling...and in liquid form, for ease in utilizing multi-component blends.

Your choice of formulations and the form in which you use them can be determined by the nature of your products and the conditions under which they are processed and stored. Technical assistance in selecting the most effective Sustane antioxidant to meet your specific requirements is available on request. Write to UOP Chemical Division, Universal Oil Products Company, East Rutherford, New Jersey 07073.

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sample, weighing approximately 10 grams, was obtained. The dish containing the weighed cheese sample was placed in a one pint Mason jar, the lid assembly was sealed, and the headspace analysis was performed.

Figure 3 is a graph showing the rate of volatilization of toluene from the stored cheese samples. The rate became constant after 25 min of heating, and thus a heating time of 25 min at 157°C was selected as optimum for maximum toluene volatilization.

While little or no browning of the cheese was observed after 25 min of heating, after 30 min considerable browning had occurred.

When the 30-min samples were analyzed, a serious "column blockage" was noted. Column blockage is caused by compounds which exhibit a great affinity for the stationary phase of the column. Thus these compounds have retention times considerably longer than the common converting solvents. If they are not eluted from the column prior to the next analysis, "ghosting," or the creation of peaks by compounds not present in the injected sample, will occur. Such "ghosting" makes analysis of the resultant chromatogram impossible.

It was felt that the column blockage was due to the volatiles produced during the browning of the cheese. Therefore, while the choice of a 30-min heating cycle would have safely assured maximum toluene volatilization, a 25-min heating cycle was chosen. The safety factor of the additional 5 min of heating was lost, but the problem of column blockage was avoided.

Jar evacuation to 20″ Hg prior to heating served to prevent leakage through over-pressures in the jar, but had no effect on the precision of the method. Deans (1967), reporting on extensive work done at DuPont in this field, substantiated this finding.

Instrumental and sensory evaluations were made daily during the storage period. A triangle test was used, and a total of 10 judgments were made on each cheese sample by a 5-member panel.

Figure 4 is a gas chromatogram obtained from the hot jar analysis of the laminate chosen for this work. Figure 5 is a gas chromatogram obtained from the analysis of a 10-gm cheese sample which had been stored in contact with the laminate for 72 hr. At this point in the storage period the triangle test first indicated a difference between treatments and controls.

Table 1 compares the instrument resonse for toluene, converted to ppm, to storage time. Arbitrary sensory ratings are included also. A rating of 1 indicates threshold, 2 is stronger, and 3 is stronger yet. The sensory threshold was reached after storage for 72 hr, whereas instrumental detection of toluene was possible even at zero hr of storage.

The film used for individually wrapping the cheese slices was a coated cellophane. When this cheese was analyzed in a blank determination, a small toluene peak was noted which could not be detected by sensory evaluations. When samples taken from the center slices were analyzed, no toluene peak was present (Fig. 6).

Table 1. GC measurement and sensory rating of toluene transfer to cheese in storage.

Storage Hours	Toluene ppm [a]	Sensory Rating [b]
0	4	–
24	20	–
48	28	–
72	39	1
96	57	2
120	69	3

[a] Average volatilized toluene as measured by the hot-jar method with a coefficient of variation of 7.1% (range 8.7–5.4%).

[b] –; not detected. 1; threshold. 2; above threshold. 3; stronger yet.

. . . and on cottonseed oil . . .

Cottonseed oil was chosen as the liquid food because of its relative resistance to reversion and autoxidative flavor changes.

Oil samples were stored as follows. 25 ml of oil were placed in a ½-pint Mason jar. The jar was then sealed using a square of the test film as a lid liner.

When the jars were inverted, 4.4

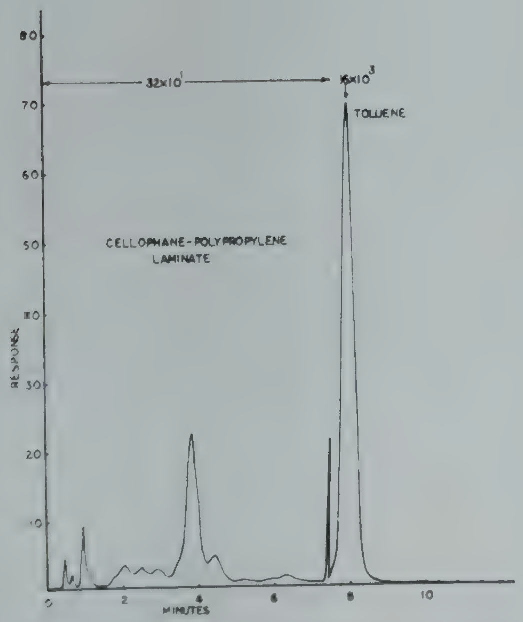


FIG. 4—*Gas chromatogram of PVDC-coated cellophane-polypropylene laminate used in the study.*

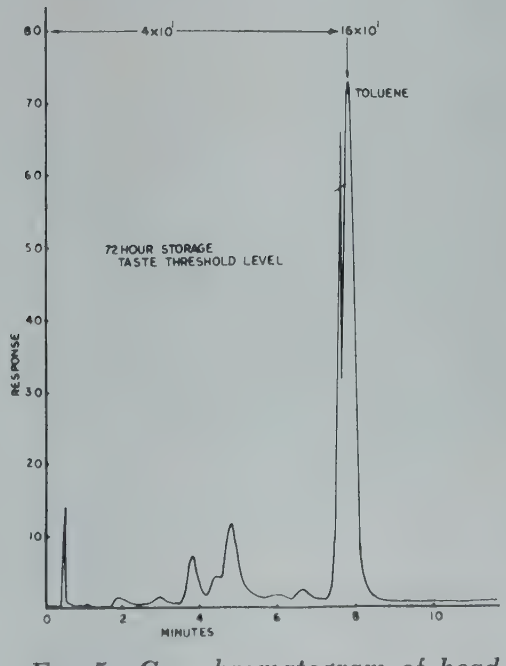


FIG. 5—*Gas chromatogram of head-space gas over 10 g cheese sample that had been in contact with laminate for 72 hours.*

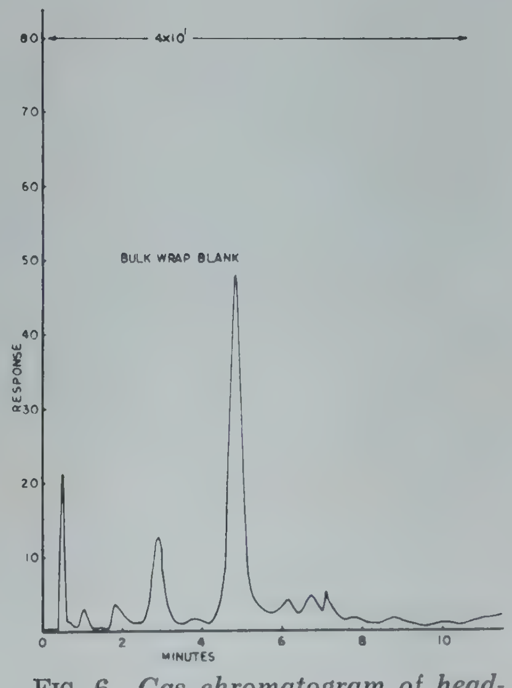


FIG. 6—*Gas chromatogram of head-space gas over 10 g cheese sample taken from center of bulk cheese. Note absence of toluene peak at 8 minutes.*

IFT WORLD

G/G/G/-- IFT 1969 ANNUAL MEETING PLANS MOVE AHEAD FOR YOUR THREE G'S --G/G/G/

■ Samuel A. Goldblith (M.I.T.), chairman of the Program Committee for IFT's 29th Annual Meeting, has announced that **"Gains, Goals & Guidelines"** has been selected as the theme. Food professionals know well that their science and technology has now become fully recognized as a vital factor in securing a world for man to live in peace and dignity. More of you are now hard at work to this end than in any other period of history, which will make this year's IFT Meeting one of the most revealing.

During this year's meeting, the accent will be on the new and its applications, placed in perspective with current social science developments and with conditions elsewhere in the world. The atmosphere for the meeting will be set in the general session to be devoted to **The Interrelationship between Food Science/Technology and The Social Sciences.**

There can be little question that we need a better understanding and a better utilization of the advances in the social sciences in order to optimize applications of food technology/science in solving some of the food problems of this world. The four aspects to be covered in this general session symposium will be a) role of the food industry in meeting the challenge of a growing society; b) role of our government in meeting this challenge; c) role of the food professional in meeting the challenge of malnutrition and its effects on social development; and d) role of social practices and cultural behavior in past and present food habits.

Practical and basic orientation have been balanced well in the selection of the other five symposia, as well as in the other technical sessions that have been scheduled. We will again have two forums:

- **Computers and computer systems in food science/technology**
  This promises to illustrate some of the more important prospects for use of computers in the food industry.

- **Food service and industrial feeding**
  Industry leaders will summarize latest views and prophesies for the institutional marketplace and for service operations in this most rapidly growing sector of food marketing.

The international yet intensely practical note is injected in the symposium

- **International feedback and good manufacturing practices**
  Here will be brought together aspects of international food law and the more important problems in food industry management with the GMP's and their interpretation in the U.S.A.

Since progress in food technology and processing depend strongly on real advances in the laboratory, four symposia have been developed to look into the future of research/methodology support for industry.

- **Rapid methods for detection of microorganisms and microbial toxins in foods**
  Several of the most promising leads to practical rapid methods will be explored. The need for rapid methods is very urgent today.

- **Freeze dried and intermediate moisture foods**
  Developments you should be aware of will be covered concerning foods for military and for industrial use at home and commercial ventures in Europe.

- **Frozen and refrigerated foods**
  The erstwhile prophesy of tremendous increases in frozen food and particularly precooked frozen food consumption in the United States is coming to pass. The special problems of frozen and refrigerated foods will have special relevance to today's practice.

- **Role of sensory evaluation in the food industry**
  A highly practical symposium will involve you by probing meaning and value of sensory testing done in industry; use and misuse in new product development, quality assurance; and bridging the hiatus between instruments and sensory test panels.

Foundations for G/G/G. Sessions this year will again be organized according to research or process discipline. In this way, all papers of common interest will be grouped together, providing optimum continuity of presentations in a session. Food professionals continually ask themselves: how much do we really know about the substance and tools of our profession? Practical success comes with fuller knowledge of the factors underlying the various processes used on food materials, and with mastery of any problems that these factors pose. Thus we need to know more about the disciplines at the base of the processes. This meeting will focus on answers to general questions of why and how, avoiding the specific commodity-oriented approach.

Work is under way in finalizing the other technical sessions.

A total concept of food transforms IFT's 29th Annual Meeting into a laboratory for exploring workable concepts

of today and tomorrow.

R.S.V.P. for Excellence. In the middle of March, an **Invitation to Attend** folder will be sent to IFT members. Titles of all technical sessions will be included, additional meeting information, and advance registration and ticket forms.

Accompanying the technical sessions at the meeting will be the Technical & Industrial Exhibit. Three months after announcement of availability of exhibit space, all booths were contracted for, and a number of additional contracts were received that could not be filled. With today's progress, pace and spread of food technology and science, the exhibit becomes even more important as an on-the-spot vital information source of practical data. A complete Exhibit Directory will be published in the April issue of *Food Technology* to help you plan your visits.

Plan Ahead. It is not too early to make plans for this investment in excellence. Time is the only commodity more precious to a food professional than his knowledge—use it wisely. A famous nutritionist once stated, "Food is not food until it is eaten." Neither are the **Gains, Goals and Guidelines** of as much value as they can be, unless they are taken and used, by YOU in person at IFT's great G/G/G meet in Chicago, May 11–15. Come!

I F T — 1969 Meeting
the Problems, the Solutions, the People
in
Chicago, May 11–15

FABRICATED FOODS: ALL-DAY NIFTY MEETING

EIGHT sessions will make up a "Meeting in Miniature" arranged by the New York Section of IFT for January 15 at the Statler-Hilton Hotel (New York City, 7th Av. at 33rd).

Speakers from industry, educational institutions and the Food & Drug Law Institute are discussing such intriguing topics as *Fabricated Foods—Who Needs Them?; Flavoring for Acceptance; Color in Breakfast Drinks; Present and Future Legal Roadblocks;* and the unravelling of a welcome mystery: *The Remarkable Success Story of C.C.K.*

For guests who come to dinner ($6.50), C. L. "Bud" MacNeilly will prescribe a cure for our machine age symptoms: move faster!

Registration at the hotel ($18 for all; $12 without dinner) or through Dr. Harold Graham, T. J. Lipton Inc., 800 Sylvan Avenue, Englewood Cliffs, N.J. 07632.

DOES YOUR WORK RELATE TO FOOD COLOR? HERE'S GOOD NEWS

THE delegates from IFT to the Inter-Society Color Council believe it is essential, if maximum use is to be made of our association with the ISCC, that we know the extent to which IFT members are involved in problems requiring evaluation of the color of foods.

We envisage our role as a clearing house for providing information and for seeking additional information by group study conducted by members of IFT interested in the solution of specific problems. To this end, we have prepared a questionnaire which will be sent on request to IFT members actively engaged in color problems.

Address your request to Dr. G. Mackinney, Chairman, ISCC delegates, Department of Nutritional Sciences, University of California, Berkeley, California 94720.

REGIONAL SECTIONS . . . . WHAT'S AFOOT

CENTRAL NEW YORK—Coming Events: *FEB.* 6 meeting will be held in Syracuse with Robert H. Stengel (Glidden-Durkee Div. of SCM) speaking on *Vegetable Dairy Systems—Today and in the Future.* The *APRIL* 10 meeting will feature Dr. Miles Sawyer, IFT Scientific Lecturer, speaking on *Practical Methods of Sensory Evaluation.* It will also be held in Syracuse.

MINNESOTA—The following meetings are scheduled for early 1969:

JAN. 20—Dr. James Jezeski, on *Current Status of the Salmonella Situation*

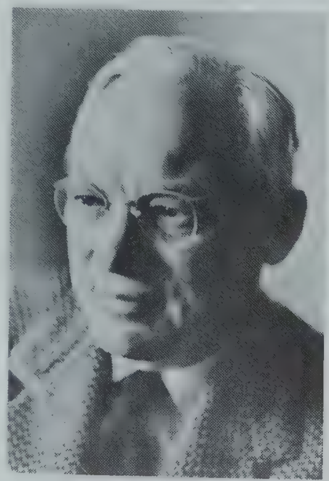
MARCH 28—Joint meeting with Northwest Section of AACC—Dr. Howard Bauman, on *Some of the Trials and Tribulations of Traveling and Doing Business in South America*

APRIL 21—Ladies' Night and Election

Dr. Maynard Amerine, IFT Scientific Lecturer, spoke at the November meeting on *Principles of Wine Making.*

NORTHEAST—At the symposium to be held on *JAN.* 21 at MIT on "Food Engineering," Dr. Marcus Karel will act as chairman. Dr. Arthur Morgan, IFT Scientific Lec-

. . . . . . more/on page 60. . . scholarships/page 59 . . .



IN MEMORIAM . . . *Dr. Mortimer L. Anson, long-time member of IFT and 1965 IFT International Awardee; at New York City. After many years of research work in proteins and enzymes, Dr. Anson was a consultant with Sidney Cantor Associates. He had also been active in assisting the USDA in its PL 480 research program in foreign countries. The beginning and success of the First International Congress on Food Science and Technology is largely credited to Dr. Anson, and he was also involved in the Second Congress in Warsaw. He was instrumental in developing the 1st International Symposium on Oilseed Protein Foods held in Japan in 1964, and was one of the founding editors of "Advances in Protein Chemistry." His life work was involved in spreading food science knowledge throughout the world. For these contributions to the dissemination of food technology, he was honored by IFT in 1965 with the International Award.*

IFT Administered / Sponsored---Fellowships / Scholarships

• CALL FOR . . .
. . . APPLICATIONS

☐ Twenty-two outstanding and deserving graduate and undergraduate students enrolled in educational institutions within the U.S. and Canada will be recipients of the 1969–70 fellowships and scholarships administered by the Institute of Food Technologists. An additional thirty students will be recipients of $500 Freshman/ Sophomore Scholarships sponsored by IFT.

Purpose of the grants is to encourage study in the field of food technology, food science and food engineering. Considerations for selection include scholastic record, over-all character and ability and at the graduate level an above-average interest in research.

Applications MUST be made on official application forms available from Department Heads, or IFT. Applications must be completed by the candidate personally and submitted to his Department Head. Department Heads, ONLY, will send completed applications and attachments to IFT.

• DEADLINE DATES—for receipt at IFT Headquarters of completed applications and all required attachments:

☐ *GRADUATE* Level—Feb. 15, 1969

☐ *JUNIOR/SENIOR* Level—March 1, 1969

☐ *SOPHOMORE* Level—March 1, 1969

☐ *FRESHMAN* Level—April 1, 1969

IMPORTANT: Incomplete applications, and applications received after the deadline date, will NOT be considered.

March *Food Technology* will carry the latest on food science/technology education . . . including IFT Education Committee recommendations on course curriculum contents . . .

GRADUATE LEVEL

FELLOWSHIP & SPONSOR (S/)	HOW MANY	STI-PEND	RENEW-ABLE?	PREREQUISITES
Florasynth Fellowship— *(S/Florasynth, Inc.)*	1	$1,000	No	Be enrolled in graduate study during tenure of fellowship; such study in food technology to be directed to extending or improving knowledge in the field (rather than related research in genetics, nutrition, horticulture, bacteriology or analytical chemistry).
General Foods Fellowship— *(S/The General Foods Fund, Inc.)*	3	$4,000	Yes; 2 times	
IFF Fellowship— *(S/IFF Foundation, of International Flavors & Fragrances, Inc.)*	1	$1,000	Yes; 2 times	
Monsanto Fellowship— *(S/Monsanto Company)*	1	$1,000	No	
Nestlé Fellowship— *(S/The Nestlé Company, Inc.)*	2	$1,000	No	
Pillsbury Fellowships— *(S/The Pillsbury Company)*	2	$1,000	Yes; 2 times	
The Samuel Cate Prescott Fellowship— *(S/Gerber Products Company)*	1	$1,000	No	

UNDERGRADUATE LEVEL—Junior/Senior

SCHOLARSHIP & SPONSOR (S/)	HOW MANY	STI-PEND	RENEW-ABLE?	PREREQUISITES
The R. T. French Co. Undergraduate Scholarship *(S/The R. T. French Co.)*	2	$1,000	Yes; 1 time	Have completed at least one term in the college where the applicant expects to graduate, prior to the effective date of scholarship; be enrolled in a curriculum leading to a degree in food technology, food science, food engineering or equivalent.
The Fritzsche Brothers, Inc.—Frederick H. Leonhardt Sr. Memorial Scholarship— *(S/Fritzsche Brothers, Inc.)*	1	$1,000	Yes; 1 time	
Gerber Undergraduate Scholarships— *(S/Gerber Products Company)*	6	$1,000	Yes; 1 time	
The Alexander E. Katz Memorial Scholarship— *(S/F. Ritter & Company)*	1	$1,000	Yes; 1 time	
Mexico IFT Section Scholarship *(S/Mexico Section 26 of IFT)*	1	$1,000	Yes; 1 time	

UNDERGRADUATE LEVEL—Freshman/Sophomore

	HOW MANY	STIPEND
IFT Undergraduate Scholarships— *(S/Institute of Food Technologists)*	30	$500

PREREQUSITES: **Freshman**—Be entering an organized program of study in food technology, food engineering, or food science; be a graduate or senior expecting to graduate from a recognized regionally accredited high school; be entering college for the first time.

Sophomore—A) Recipients of Freshman Scholarships (above)
B) First-year students with a 2.5 average (A = 4.0, B = 3.0, etc.); recommended by Dept. Head; must be pursuing food technology curriculum or equivalent.

turer, will speak in the evening on *Basic Innovations in Food Processing.* Officers of the section are Kirby M. Hayes, chairman; Kenneth T. Farrell, vice-chairman; Paul Cormack, treas.; and Sanford A. Miller, secy.

NEW YORK—Dr. Timothy W. Costello, Deputy Mayor–City Administrator, spoke at the November meeting on *Industry and the Urban Crisis.* At the seminar program during the meeting, W. Hagan (Nestlé Corp.) talked on *Simple Statistics for Paired Comparison and Hedonic Scale Sensory Testing,* and R. Fox (T. J. Lipton, Inc.) on *Creating and Marketing of New Products.*

OREGON—Meetings have been tentatively scheduled for the following dates:
FEB. 1—High School Career Day, Corvallis
FEB. 10—Salem
MARCH 10—Portland
APRIL 14—Albany
A luncheon meeting during NWCF annual meeting was held early in January. The annual Christmas party took place in early December. A wine tasting session and a talk by Richard Sommers, Hillcrest Vineyards, on *Problems and Pleasures of Growing Grapes and Production of Wine in Oregon* were the special features of the November meeting. The annual scholarship award dinner took place in October with Dr. Milton Valentine discoursing on *On the Care and Feeding of Dragons.*

PUGET SOUND—Frank Herwatt, Fritzsche Bros., presented Dr. Ernest Gunther's film on *The Essential Oils of Central and South America* at the October meeting. New officers for the year are: Chairman, Dr. Jack Matches; Chairman-Elect, Paul Taylor; and Secy.-Treas., George Miller.

SOUTHERN CALIFORNIA—Ladies' Night with a special program was held in December on the SS Princess Louise. "Adventures in Food Technology" was the theme of the all-day November meeting. Specific topics covered were meat and dairy products, fruits and vegetables, packaging and frozen foods. Dr. Dale Sieling, scientific director of U.S. Army Natick Labs., was the guest luncheon speaker. Suppliers' Night with displays and talks on products and services took place in October. Fred E. Porner, Hunt-Wesson Foods, spoke on *Prospects of Food Packaging in Vinyl Plastics.* A question and answer period followed his presentation. The June field trip combined a tour of Laura Scudder's processing plant with one of the Hoerner-Waldorf Corp. fiber container plant at Anaheim.

WESTERN NEW YORK—A one-day "Aseptic Food Processing" symposium, sponsored by the section, will be held on *MARCH* 19 at Rochester. The program will cover the following: *Aseptic Canning Theory and Process* by F. M. Johnson; *Pre-Process of Particulate and Liquid Material* by D. C. Roahen; *Aseptic Tomato Paste Flash Coolers* by A. L. Feltz; *Aseptic Drum Filling and Correlated Processing* by V. R. Carlson; *Rigid Containers for Aseptic Food Processing* by M. E. Seehafer; and *Profit Potential for the Food Processor Using Aseptic Canning Methods* by F. M. Johnson.

WISCONSIN—Coming Event: The next scheduled meeting will be held on *MARCH* 14. Following a tour of the Bjorksten Labs, Dr. Karl Gunther spoke at the November meeting on *Proteins from Petroleum.*

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Thermal Destruction and Regeneration of Enzymes in Green Bean and Spinach Puree

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SUMMARY

Green bean and spinach purees were adjusted to pH 8.3, placed in glass capillary tubes and processed in a glycerol bath at temperatures up to 350°F. An accurate heat penetration and lethality calculation enabled process values to be calculated for total processing time as low as 1 to 2 sec. Assays for peroxidase showed a z value of 88 and 29 for green bean and spinach purees respectively. Spinach chlorophyllase had a z value of 22. An Fo process value of 5.0 was sufficient to prevent regeneration of peroxidase in spinach at temperatures up to 290°F. With green beans at temperatures of 270 and 290°F, process values of 31 and 245, respectively, were required to prevent peroxidase regeneration. All samples of spinach or green beans which showed no peroxidase regeneration were also negative for catalase. The gross overprocess required to prevent peroxidase regeneration in green beans would effectively rule out this product as a candidate for High-Temperature Short-Time processing.

INTRODUCTION

The use of High-Temperature Short-Time (HTST) methods to process vegetables is usually superior to conventional retort processing in maintaining natural flavor, color and heat sensitive nutrients. However, commercial sterilization of a product by HTST methods does not necessarily inactivate all the enzymes which are known to be involved in production of an off-flavor. At processing temperatures above 255°F, it is essential that a thermal process be adequate to inactivate the enzymes present as well as ensure microbial destruction.

The advantages inherent in the HTST processes lead to a desire to raise processing temperatures as high as practicable. With vegetables containing chlorophyll, there is considerable gain in color quality if the product is adjusted to an alkaline pH prior to processing. This study was designed to provide data on enzyme destruction and regeneration, at processing temperatures up to 350°F, in green bean and spinach purees adjusted to pH 8.3.

A great deal of work has been done on the relationship between enzyme activity and development of off-flavor during storage (Esselen *et al.*, 1954a, 1954b; Guyer *et al.*, 1954; Labbee *et al.*, 1954; Lindquist *et al.*, 1951). The enzymes usually involved are peroxidase, catalase and lipoxidase.

With conventional retort processing a thermal process sufficient for microbial destruction is usually also adequate for enzyme destruction. However, since the z (°F required for the thermal destruction curve to traverse one log cycle) values characterizing destruction of enzymes are usually higher than those characterizing destruction of microorganisms, it may also be necessary to establish thermal processes for enzymes as well as microbial destruction (Esselen *et al.*, 1956; Farkas *et al.*, 1956; Guyer *et al.*, 1954; Vetter *et al.*, 1958).

The problem of enzyme inactivation is complicated by two factors. Firstly, the thermal resistance of enzymes, particularly peroxidase, varies considerably even among varieties of the same vegetable (Esselen *et al.*, 1956). Secondly, the enzymes may regenerate and develop activity on storage even though no activity can be demonstrated immediately after thermal processing (Joffe *et al.*, 1962; Vetter *et al.*, 1959; Wilder, 1962; Zoueil *et al.*, 1958).

Esselen *et al.* (1956) reported that, in the temperature range 215–290°F, a process to prevent regeneration was 2 to 4 times as great as that required to inactivate the enzymes, as determined immediately after processing. With green beans and turnips, the process may be up to 6 times higher (Zoueil *et al.*, 1958). Esselen (1950) attributed the regeneration to a reversion of the denatured protein to its native state after heating and cooling. Vetter *et al.* (1959) compared the thermal destruction curves for corn peroxidase, one to prevent activity immediately after processing and the other to prevent regeneration. The two were almost parallel and one was two times greater than the other between 240 and 270°F and six times greater at 300°F. They explained the regeneration phenomena as the ability of the enzyme molecule to regain its helical shape and form enzyme-substrate complexes.

The need for more severe processes to inactivate enzymes than is required for microbial destruction, as the processing temperature is raised, is obviously very important in HTST processing and little information is available for vegetable products in the temperature range of 300 to 350°F.

The advantages of adjusting the pH of a green vegetable puree to maintain a better color are well established (Clydesdale *et al.*, 1968; Gupte *et al.*, 1964). Little information is available on the effect of raising the pH value

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on the thermal destruction kinetics of the enzymes.

The enzyme chlorophyllase which occurs naturally in many green vegetables including spinach removes the phytyl chain from both chlorophyll and pheophytin resulting in the formation of a green pigment called chlorophyllide. A prolonged blanching treatment results in appreciable formation of chlorophyllide in spinach puree and the process has been studied as a possible way to improve the color (Clydesdale *et al.*, 1968). Information on the heat stability of the enzyme is necessary to assess its possible effect during processing.

MATERIALS AND METHODS

Raw materials. Bulk spinach and green beans, obtained from the wholesale market, were washed, trimmed and pureed in a Fitzpatrick Mill (Model M., W. J. Fitzpatrick Co., Chicago, Illinois) using a coarse screen and then a No. 40 fine screen. The pH of the puree was adjusted to approximately 8.3 by adding one g of magnesium carbonate to 300 g of puree. The alkalizing agent was dispersed using an Omni-Mixer (Ivan Sorvall, Inc., Norwalk, Conn.) with the cup in an ice bath to prevent a temperature rise. The puree was stored in 100 g lots in polyethylene bags at −20°F until required.

Capillary tubes. The sample of puree was thawed at room temperature and deaerated under vacuum (Tan *et al.*, 1962). Borosilicate glass tubes with outer diameter 1.5 to 2.0 mm and 10 cm in length with one end sealed were used as containers.

The spinach puree was introduced into the tubes to a 3.7 cm depth with a 5 cc syringe and a 20 gauge needle, but the green bean puree was too fibrous for this method. The bean puree was placed in an aspirator flask with a 20 gauge needle through the rubber stopper. A bundle of 50 capillary tubes were secured to the needle inside the flask above the level of the puree. A vacuum was drawn through the needle and, after three evacuations to remove all oxygen, the capillary tubes were lowered into the puree. When the vacuum was broken with nitrogen, the puree entered the tubes. After removal from the flask, the level of the puree in each tube was adjusted to approximately 3.7 cm with the same needle in a stream of nitrogen. In some cases it was necessary to centrifuge the tubes to drive the puree to the bottom of the tubes. After filling, each tube was flushed with nitrogen and sealed in a gas flame. The sealed tubes were approximately 7.5 cm long with a 3.7 cm column of puree.

Thermal treatment. A modified Stern *et al.* (1954) apparatus was used to heat the capillary tubes. This apparatus consists of carrier bars to transfer tubes from the heating bath to a cooling bath very rapidly. The time in the heating bath, and the transfer time between baths was determined accurately by microswitches activating sensitive timers. The modifications were minor and consisted of (1) larger, 1 gal, baths; (2) replacement of the eccentric cam braking device with a bar and spring to reduce the shock; and (3) relocation of one of the three microswitches on the frame. A detailed description is available (Resende, 1966). Each capillary tube was held in a rubber stopper in the carriage such that the tube penetrated approximately 7 cm into the heating medium. Glycerol was used in the heating bath to facilitate heat transfer and ice water was used in the cooling bath. The carriage held five stoppers such that five tubes could be heated in one test.

With capillary tubes and temperatures up to 350°F, the whole thermal process required for microbial inactivation is likely to be accomplished in the heating and cooling phases. Consequently, an accurate method of evaluating thermal process is essential. It is described by Resende *et al.* (1969).

Peroxidase activity. The peroxidase activity was measured with a modification of the method of Robinson (personal communication, 1964). It is essentially the utilization rate of hydrogen peroxide to form the colored product tetraguaiacol from guaiacol. The time required to increase absorption at 450 mm in phosphate buffer at pH 7, was a measure of the enzyme activity (Resende, 1966). Five capillary tubes, replicated three times, were used for each assay.

Catalase activity. Qualitative tests for catalase activity were performed by the method of Gagnon *et al.* (1959).

Chlorophyllase activity. Chlorophyllase was estimated by a method similar to that of Holden (1961, 1963). The puree was extracted with acetone to remove the pigments, suspended in 0.1 M Tris buffer at pH 8 and incubated with pheophytin substrate with agitation for 30 hr. The reaction was stopped with acetone and the remaining pheophytin extracted with petroleum ether. The loss of pheophytin was a measure of the enzyme activity (Resende, 1966). Pheophytin was estimated using an extinction coefficient of 63.6 L/g at 667 mm (Klein *et al.*, 1961). Pheophytin a, obtained by acid hydrolysis of spinach chlorophyll a by the method of Tan *et al.* (1962), was preferred to chlorophyll a for assay of chlorophyllase activity because of its greater stability. Five tubes, replicated three times, were used for each assay.

Table 1. D values for green bean peroxidase computed with lethal rate paper with $z = 88$ and $D_{220} = 45$.

Temperature (°F)	D value
220	50.0
230	40.0
250	26.5
270	8.85
290	4.33
310	4.13
330	3.65
350	1.66

Thermal destruction time (TDT) curves. The D values for the enzymes were obtained by calculating the time required at a given temperature to reduce the activity to 10% of the initial value. A plot of D vs. temperature provided the TDT curves. The thermal destruction time regression equations were calculated by the method of least squares.

Enzyme regeneration. In order to determine the value of a process sufficient to prevent regeneration of peroxidase, the green bean puree was heated at individual temperatures within the range 220 to 350°F for different lengths of time. The heating times were chosen such that they would be multiples of D and Fo values could easily be calculated. The tubes were stored at 75°F after processing and sampled for peroxidase activity at 0

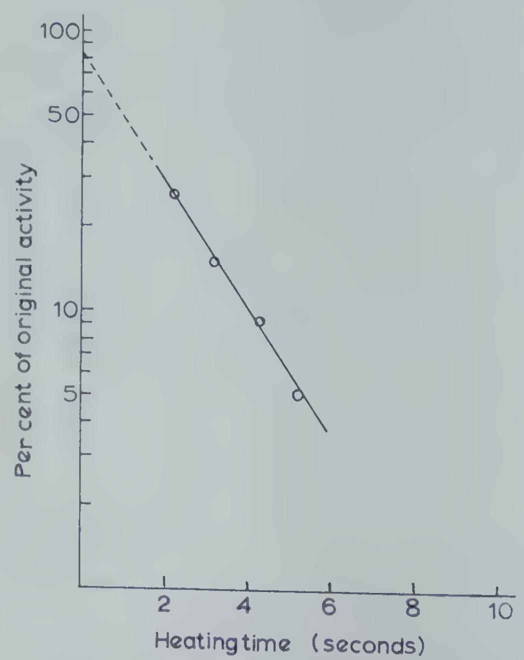

Fig. 1. Rate of inactivation curve for green bean peroxidase at 290°F.

Table 2. D values for spinach peroxidase and chlorophyllase.

Temperature (°F)	D value peroxidase [1]	Chlorophyllase [2]
170	7.05	
177	4.43	
184	2.79	60.0
191		7.7
198	0.76	5.3
205		5.4

[1] Calculated with lethal rate paper z = 32 and D170 = 7.56.
[2] Calculated with lethal rate paper z = 18 and D184 = 50.

Table 3. Regeneration of green bean peroxidase after 72 hr of storage at 75°F.

Temperature (°F)	210	230	250	270	290	310	330	350
Heating time (multiples of D)	Percent of Original Activity							
3	5.0	3.0	2.0	2.5	3.5	3.0	....	....
6	2.0	2.0	1.0	1.0	1.5	1.3	6.0	6.0
8	1.6	2.0	0.5	0.3	0.8	1.0	2.0	4.0
10	1.0	0.5	0.3	0.2	0.5	0.8	0.8	1.2
12	0	0	0	0	0.5	0	0.3	0.7
14	....	....	....	....	....	....	0.2	0.2
16	....	....	....	....	....	....	0	0

and 72 hr.

The spinach puree was given a process of approximately $F_0 = 2.5$ and 5.0 sufficient to destroy 10^{12} spores of *Cl. botulinum* and P.A. 3679, respectively. Temperatures of 250, 270, and 290°F were used for processing with storage and sampling similar to bean puree.

RESULTS AND DISCUSSION

Peroxidase inactivation. A summary of the D values for green bean peroxidase is presented in Table 1. The actual data from which these D values were calculated are presented in the accompanying paper on methodology (Resende *et al.*, 1968). A typical TDT curve is shown in Fig. 1. The z value calculated from the D values was 88. A range of z values from 42 to 100 for peroxidase in vegetables has been reported in the literature (Farkas *et al.*, 1956; Vetter *et al.*, 1958). Esselen *et al.* (1956) working in the temperature range 215 to 300°F, reported a range of z values from 44 to 80 for inactivation of green bean peroxidase and 23 to 65 to prevent regeneration. Zoueil *et al.* (1958), working in the temperature range 180 to 260°F, reported a z of 41 for inactivation and 47 for prevention of regeneration of green bean peroxidase. The z value of 88 obtained in the present work for inactivation is higher but the temperatures were higher and the pH was adjusted to 8.3. Also the method of process calculation may have been more accurate.

The rate of inactivation of bean peroxidase did not follow a first order reaction from the line of zero heating time since the curves did not cross this line at the point of 100% of original activity. This phenomenon has been reported a number of times before and two general theories have been developed to explain it. The presence of two or more reaction rates could be due to the multiple nature of the peroxidase molecules, each with a different thermal stability (Yamamoto *et al.*, 1962). The multiple nature of peroxidase is well established (Jermyn *et al.*, 1954). Another theory postulated the existence of an enzyme-complex which would create a protective mechanism for the enzyme against heat (Yamamoto *et al.*, 1962; Farkas *et al.*, 1962). Both theories could fit the present data with peroxidase in green bean puree at 8.3 with processing temperatures up to 350°F.

Similar data for spinach peroxidase are presented in Table 2, and Fig. 2. The z value was calculated to be 29, a much lower figure than that for green bean peroxidase. The rate of inactivation curves crossed the zero heating time line at a point above the 100% of original activity. The greatest deviation was evident in the curve at the highest heating temperature. This may be due to the increased error involved in the very short total heating and cooling times (1.2 to 2.0 sec). An attempt was made to obtain rate of inactivation curves for spinach peroxidase at temperatures below 170°F where longer heating times could be used. However, below 170°F, the rate of inactivation was not first order. A typical test at 134°F is shown in Fig. 3.

Peroxidase regeneration. Table 3 presents data on the regeneration of green bean peroxidase. Table 4 presents the process values required to prevent regeneration at 3 temperatures. In the temperature from 220 to 310°F, a process of about 12 D was necessary to inactivate the enzyme to the point at which regeneration did not take place during storage at 75°F for 72 hr. In the temperature range 330 to 350°F, a process of about 16 D was required for the same purpose.

Table 4 also lists the F_{so} process required to prevent enzyme regeneration. At 290°F an F_{so} of 245 would be required. This is obviously a gross over-processing from the standpoint of sterilization and would effectively rule out green beans as a candidate for HTST processing. Data in the present work were obtained with green bean puree buffered at pH 8.3. However, the thermal destruction times are not likely to be less for puree at the natural pH, which is closer to the pH

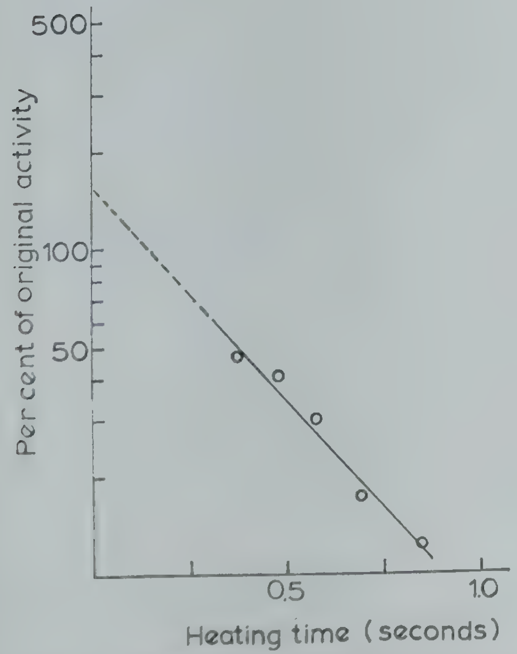

Fig. 2. Rate of inactivation curve for spinach peroxidase at 198°F.

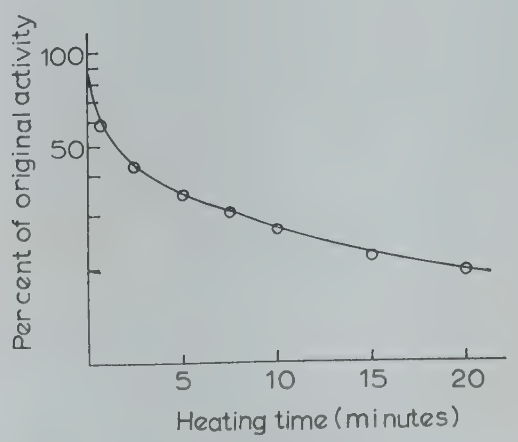

Fig. 3. Rate of inactivation curve for spinach peroxidase at 138°F.

Table 4. Thermal process sufficient to prevent regeneration of green bean peroxidase.

Temperature (°F)	Time (sec)	Process value [1] (Fo)
250	210	3.5
270	132	31
290	82	245

[1] 12 D with z = 18.

Table 5. Times and temperatures to provide Fo = 2.5 and 5.0 for spinach puree in capillary tubes.

Temperature (°F)	Process Value Fo = 2.5	Fo = 5.0
	Time (sec)	
250	150	300
270	13	24
290	3	4

optimum for peroxidase.

Table 5 presents data on the time required to obtain a process $F_0 = 2.5$ and 5.0 for spinach puree in capillary tubes at temperatures of 250, 270, and 290°F. No regeneration of peroxidase could be demonstrated in any sample. Consequently, at least with temperatures up to 290°F, the conventional Fo = 5 process would be adequate to prevent peroxidase regeneration. This would make spinach puree a good candidate for HTST processing.

The fact that an F_{80} process value of 245 at 290°F is required to prevent all peroxidase activity does not preclude the fact that a slightly lower process might be tolerated. One unanswered question is the relationship between the degree of peroxidase regeneration and the degree of off-flavor. This obviously would be influenced by time and temperature of storage and must await the development of a practical system to process sufficient products at 290°F to allow taste panel studies.

Chlorophyllase inactivation. Fig. 4 presents a rate of inactivation curve for spinach chlorophyllase at 184°F. Table 2 lists D values for spinach chlorophyllase. The z value calculated from the D values was 22. The TDT curve could not be extrapolated below 184°F because the first order inactivation rate did not hold. The rate of reaction decreased with time of heating in the same manner as spinach peroxidase. A large variation was noted between replications of the same treatment probably because of the low activity of the enzyme and the consequent difficulties in assay. Assay incubation times as long as 30 hr were necessary and the enzyme is rather unstable during preparation. For example, all activity was lost if the pigment-free powder was allowed to dry in air. Freezing the powder would also destroy the activity. This enzyme is very heat-labile and normal retort temperatures would inactivate it very quickly.

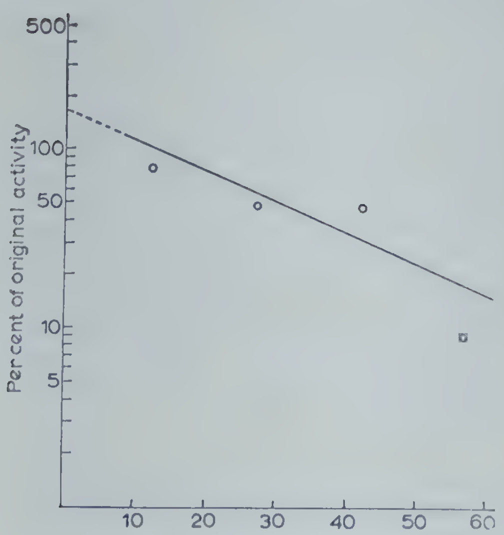

Fig. 4. Rate of inactivation curve for spinach chlorophyllase at 184°F.

Catalase inactivation. Catalase activity was assayed at 0, 6, 24 and 72 hr after processing only in those samples which showed no peroxidase regeneration. All of the samples of both green beans and spinach which showed zero regeneration for peroxidase also showed no catalase activity. Catalase must be less heat stable than peroxidase in both products.

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Ecosystems of Food-Contact Surfaces

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SUMMARY

The ecosystem of product-contact surfaces of food processing equipment was simulated on glass and stainless steel slides. Interactions between microorganisms, milk films, milk solids in suspension, sanitizer residues in presence of milk soil and soil residues on washed surfaces were studied. Bacteria on milk films showed a low capacity for survival, with no apparent correlation between available soil and bacterial growth. Drying of the soil:bacteria menstruum upon surfaces produced an environment in which a direct relation occurred between microbial growth and soil present. On washed, visibly clean surfaces, survival and growth of bacteria was possible, though largely governed by the nature of the surface. Sanitizers differed in their surface bactericidal activity, and further differences were related to the type of surface to which they were applied.

INTRODUCTION

Microorganisms found upon food-contact surfaces, such as in a dairy plant after cleaning and sanitization, exist in a complex environment where surfaces, soil residues, detergent residues, moisture, temperature, the population density of the microorganisms and various other factors influence each other. When several biotic and abiotic elements interact in a limited space, the sum total of their interactions may be called an "ecosystem" (Brock, 1966). Ecosystems have phase boundaries separating them in some way from the outside world, and since the environment of a single microorganism is of minute dimensions, there can be several ecosystems in a relatively small area, each of which may be dissimilar from the other.

On applying this term to product-contact surfaces, we have what may be known as the "hard surface ecosystem." This system maintains an equilibrium controlling microbial survival, if not actual proliferation, and this fact is of importance in the field of sanitary regulations and quality control. Hence an adequate explanation for the persistence of a microflora after cleaning and sanitization is highly desirable. The present investigation was designed to provide data on the interaction of some of the factors related to the persistence of the microflora.

Food-product residues, detergent residues and various ions contributed by rinse water comprise the soil of food-contact surfaces. Efficient cleaning is necessary to remove the soil. Several workers (Kaufmann *et al.*, 1960a; Kaufmann *et al.*, 1960b; Thomas, 1963) have shown that following cleaning with relatively efficient use of detergents, there can be a gradual buildup of residual soil that resists removal and may support microbial growth.

Other investigators (Holland *et al.*, 1953; Kaufmann *et al.*, 1960a) have attempted to relate soil buildup to the bacteriological condition of surfaces and found that there is no obvious correlation. The basis for their studies was visual inspection, a method considered somewhat less reliable than others (Jennings, 1965). A closely related aspect to soil removal has been determination of the rate and extent to which bacteria may be removed from soiled surfaces, the term generally applied being "bacterial cleanability" (Hays *et al.*, 1958; Hays *et al.*, 1960; Masurovsky *et al.*, 1958; Pflug *et al.*, 1961; Ridenour *et al.*, 1953).

Little has been done, however, to determine the pattern of survival and growth of microorganisms on surfaces apparently free of all residues. This phase could assume greater significance in conjunction with a wider appreciation of the existence of two soil species in any soiling situation (Jennings, 1965), one of which is extremely tenacious.

The use of bactericidal agents as sanitizers is an essential part of the sanitation process. From the work of several investigators (Gemmill, 1955; Havighorst, 1951; Maxcy, 1964; Maxcy *et al.*, 1961; Olson *et al.*, 1960; Thomas, 1963; Thomas *et al.*, 1964), it is clear that adequate sanitization does not preclude a bacterial flora on food-contact surfaces, and certainly is not synonymous with sterility.

Klarmann *et al.* (1953) have emphasized that the continuing antibacterial effect of a surface application of disinfectant is of greater significance than simple disinfection. An indirect recognition of this could be reflected in the current practice of sanitizing immediately after cleaning, as is a common practice with bulk-tanks.

It is commonly recognized (Dyson, 1961; Hoy *et al.*, 1955; Jennings, 1965) that organic matter influences bactericidal activity of sanitizer solutions. Studies on continuous liquid systems indicate a reduction in activity, and some studies on pipeline systems (Maxcy, 1966) also confirm this. However, Wolf *et al.* (1946) have postulated that interactions of the hypochlorite ion with milk residues result in the formation of stable chloramine, thus enhancing bactericidal action by adsorption on cell surfaces.

As far as is known, no investigations have attempted a correlation between variation of organic residues on surfaces and changes in the antibacterial potential of sanitizers.

In the light of these facts, the present study was undertaken with a view to assessing the following: (a) the effect of dried milk films of known character and milk solids in suspension on surfaces, upon the survival and growth of bacteria ; (b) survival and growth of microorganisms on surfaces washed free of milk films and (c) the combined influence of milk solids and sanitizer residues on survival and growth of microorganisms.

EXPERIMENTAL METHODS

Milk films on surfaces. Microslides were cleaned thoroughly to obtain perfectly wettable surfaces. Slides were stored in deionized distilled water to preserve wettability, ensure ionic neutrality and to maintain the high degree of cleanliness. Before use, each slide was rinsed in 100% ethanol and flamed prior to placing in a sterile petri plate. Surfaces were soiled with sterile whole milk. Soil increments were approximated by number of milk drops and assessed quantitatively by weighing to 0.1 mg after uniformly spreading the films to cover an exact area, taking care to obtain adequate drying before weighing.

Each film was uniformly coated with 0.01 ml fresh raw milk having a bacterial count of approximately 200×10^3 organisms per ml, then permitted to dry. The slides were incubated for

24 hr at 32°C and the fate of the microflora was subsequently evaluated.

Soil:bacteria menstruum on surfaces. A series of dilutions was prepared from low heat Grade "A" non-fat dry milk to contain from 0.0 to 0.16 g/ml of solids (referred to, hereafter, as NFDM solids). Washed cell suspensions of *Escherichia coli, Microbacterium lacticum, Pseudomonas fluorescens* and *Streptococcus lactis* were used to inoculate the milk solutions to produce population densities of 50 to 100 organisms per ml. Glass and stainless steel slides of similar dimensions were used as test surfaces. They were placed in sterile petri plates after cleaning and sterilization, and 0.5 ml of the soil:bacteria menstruum was added aseptically and spread over each surface with the tip of the pipet. Visible moisture evaporated in approximately 48 hr; an additional 24 hr was allowed for interactions of bacteria, soil and substrate, after which enumeration of the bacterial populations was undertaken.

Washed surfaces. Glass and stainless steel slides were soiled with sterile whole milk by immersion and immediate removal, followed by draining of excess milk and drying of the adhering layer into a uniform film with air (40°C) from a mechanical blower for 40 to 80 sec. Repetitions enabled the production of a series of films of increasing thicknesses. Slides were washed to produce visible cleanliness by immersing for 1–2 min in a 1% alkaline cleaner solution agitated in a Waring Blendor jar at medium speed. Each slide was then rinsed in distilled water at a slower speed. Slides were dried in an oven at 100°C for 10 min.

Cell suspensions of *E. coli, M. lacticum, P. fluorescens* and *S. lactis* were prepared in deionized distilled water, and each was separately standardized to provide an inoculum of approximately 100 cells per ml from which 0.5 ml was taken for each surface. The inoculum was spread uniformly, dried visibly within 48–96 hr and then incubated at 32°C for 24 hr. Survival and growth of the organisms on the surfaces was then estimated.

Soil-sanitizer interactions. After cleaning and sterilizing glass and stainless steel slides as described previously, two sets of slides for each material were prepared. One set was treated with calcium hypochlorite and the other with a quaternary ammonium compound (QAC). Each solution contained 200 ppm of active ingredient. The contact time was 2 min after which the slides were removed, excess moisture was drained off and each was placed in a sterile petri plate. A series of dilutions was prepared from sterile whole milk to include a range of 0.5 to 50.0 μg solids per ml. A raw milk microflora was introduced into each dilution to give approximately 90 organisms per ml. Each sanitized surface was uniformly covered with 1.0 ml of inoculated soil suspension, which was then permitted to dry. After approximately 12 hr incubation, the microbial population of the surfaces was determined.

Table 1. The fate of bacteria in varying quantities of milk soil in films.

Soil weight	Bacterial count	Soil weight	Bacterial count
0.0024	1	0.0048	10
0.0028	2	0.0078	19
0.0031	1	0.0079	0
0.0034	4	0.0089	2
0.0035	1	0.0167	9
0.0035	7	0.0172	5
0.0043	1	0.0187	10
0.0046	61	0.0204	3
		0.0256	30

Surface estimation of bacteria. A modified direct surface agar technique (Angelotti *et al.*, 1957) was used for directly estimating and enumerating microorganisms used in this study. Standard Plate Count agar (American Public Health Association, 1960) at 43°C was placed directly on each slide, approximately 3 ml being required entirely to cover glass surfaces and 5 ml for stainless steel surfaces. Incubation at 32°C for 48 hr resulted in the production of discrete or diffuse colonies, dependent upon various factors. The use of a Quebec colony counter helped in quantifying results.

RESULTS

Microorganisms on milk soil films. The fate of raw milk microorganisms was determined in low concentrations of milk soil as films to simulate the residues of poor washing. Typical data from 10 trials with 8–10 soil increments each are given in Table 1. The range of soil-film weights was from 0.0024 g/ 23 sq cm to 0.0256 g/23 sq cm, all films being clearly visible to the unaided eye. The microflora on the films encompassed the gamut of raw milk microorganisms. At the soil levels indicated, which are of immediate interest to sanitarians, bacterial populations diminished, and the total surviving population on any surface showed no relation to the total soil present.

It would appear that nutrient availability was inadequate or that the total environment was unfavorable for microbial growth. Further, no particular species was found to be selectively dominant, judging from observations of the survivors. These data demonstrate that adequacy of nutrients on soiled surfaces is not the sole factor responsible for bacterial survival and that other ameliorative factors in the total environment also are involved.

Soil:bacteria menstruum on hard surfaces. The effect of varying amounts of non-fat dry milk solids on a bacterial population after drying upon glass and upon stainless steel surfaces was studied. In Table 2, data from one of several trials run in triplicate and averaged have been given, and show the nature of survival and growth of raw milk microorganisms on stainless steel surfaces. Glass surfaces gave very similar results.

It is apparent here that bacterial proliferation is in direct proportion to available nutrients, quite unlike the preceding observations where bacteria were placed on prepared milk films. Up to a level of 0.02 g/26 sq cm, soil levels per unit surface area are approximately the same in this and the preceding experiment; hence, factors other than soil level would explain the linear relationship observed. It seems that either intimate mixing of soil and bacteria during the drying phase, or the presence of moisture during the relatively prolonged drying period, was responsible for this.

It was also apparent that active multiplication of organisms occurred only above a particular soil level, *viz.*, 0.02 g/26 sq cm, indicating a critical level for inoculated soils dried upon surfaces. A gradient pattern is generally discernible for each organism, and while these represent species with widely different nutritional requirements, the levels of population attained at a particular soil concentration are roughly similar.

Note was made, with no explanation, of the limited growth of *M. lacticum* at a NFDM concentration of 0.080 g/26 cm. Stainless steel and glass showed no differences in growth under the conditions of this experiment. The results could be attributed to a limited surface-bacteria interaction, or none at all. Results tend to emphasize the importance of the overall environment relative to the magnitude of individual factors.

Bacteria upon washed surfaces. Results from two trials run in triplicate and averaged are given in Table 3, which shows the survival and growth of *P. fluorescens* on glass and stainless

Table 2. Survival and growth of microorganisms on hard surfaces with non-fat dry milk solids.

Non-fat dry milk solids (g/26 sq cm)	Average bacterial count [1]			
	Escherichia coli	*Microbacterium lacticum*	*Pseudomonas fluorescens*	*Streptococcus lactis*
0.00	0	0	0	0
0.005	+	+	+	+
0.020	+++	+++	++	++
0.040	+++	+++++	+++	+++
0.060	++++	++++	+++++	++++
0.080	++++	++	+++++	+++++

[1] Colony estimates of triplicates.
0 No growth
+ < 50
++ 50–100
+++ 100–300
++++ 300–500
+++++ > 500

Table 3. The effect of surface and soil films on the fate of *P. fluorescens.*

Soil films originally present	Glass: Average bacterial count	Stainless steel: Average bacterial count [1]
0	0	++
1	1	++++
2	0	+
3	5	++
4	0	+
5	0	+
6	1	+
7	0	++
8	0	+
9	0	+
10	0	+++

[1] Growth density estimates of triplicates.
0 No growth
+ Very light
++ Light
+++ Medium
++++ Heavy

steel surfaces from which milk films of different thicknesses were removed by a standard washing procedure. Data for other species studied, *viz., E. coli, M. lacticum* and *S. lactis* were similar.

The nature of the surface shows a marked effect on microbial activity, an indirect indication of the soil-retentive capacity of the surface. Stainless steel consistently had greater bacterial populations than glass; in fact, the bacterial population on glass had diminished to zero in almost all cases while actual multiplication had taken place on stainless steel in several instances. However, microbial survival and growth was quite random in that no significant correlation could be seen between the amount of soil originally present and populations on the corresponding washed surfaces.

The use of bacterial suspensions in deionized distilled water permitted evaluation of the capacity of washed surfaces to support microbial populations while minimizing the influence of nutrients (organic) or ions adsorbed onto bacterial cells. Information obtained emphasizes that hard surfaces, such as food-contact surfaces, visibly free from soil residues after washing, are quite capable of supporting microbial growth subject to their individual capacities for retaining the invisible and tenacious soil.

Antibacterial potential of sanitized surfaces. The influence of soil-sanitizer interactions on bacterial survival and growth on stainless steel and glass surfaces was determined. In Table 4, averaged results from a set of triplicate trials have been presented.

On glass surfaces there was limited growth with the control as well as with either of the added sanitizers. Results on stainless steel showed a diminishing antibacterial activity with increasing soil level. On stainless steel the residual effect of chlorine was somewhat lower than that of QAC, particularly at soil levels in the region of 2.4 to 20.0 μg/ml. Above 30.0 μg/ml soil, heavy bacterial growth occurred, indicating a very adequate nutritional environment and a complete masking of the antibacterial effect of the two sanitizers. These observations showed that considerable importance attaches to the nature of the surface in the bactericidal evaluation of surface-applications of sanitizers.

DISCUSSION

The presence of soil as dry film upon a surface presents an environment different from that of films formed after natural drying of a soil: bacteria menstruum, as seen by comparisons of bacterial populations after incubation. It appears that moisture plays a significant role in these differences. Thus, the consideration of the food-contact surface in terms of ecological relationships assumes a significance not previously emphasized.

From study of a wide range of soils, substrates and cleaning conditions, it has been concluded that in any soiling situation two soil species occur, one of which is extremely tenacious and represents a more orderly and coherent arrangement of molecules (Jennings, 1965). This is apparently related to the behavior of washed surfaces as substrates for bacterial proliferation. Differences between glass and stainless steel surfaces appear to arise from the nature of adsorption, a factor noted by others (Harris *et al.*, 1961; Hensley, 1951; Hensley *et al.*, 1949) to be of primary significance in the retention of soil.

In the work on soil-sanitizer interactions, the greater antibacterial potential of QACs as compared with chlorine shown by Klarmann *et al.* (1953) was confirmed. Maxcy (1966) has shown that minute quantities of organic residues on surfaces dissipate the hypochlorite ion, but it is also clear

Table 4. Bacterial survival and growth in presence of milk solids and sanitizer residues.

Milk solids (μg/ml)	Average bacterial counts [1]					
	Glass			Stainless steel		
	Control	Chlorine	QAC	Control	Chlorine	QAC
0.5	0	3	0	+	0	0
1.2	2	1	0	+	0	0
2.4	0	0	0	++	+	0
4.8	0	1	2	+++	0	+
9.6	0	0	0	+++	+	0
20.0	5	3	3	++	+	0
30.0	2	4	0	+++	+++	+++
40.0	5	2	1	++++	++++	+++
50.0	+++	+++	+	+++++	+++	++++

[1] Growth density estimates of triplicates.
0 No growth
+ Light
++ Medium heavy
+++ Heavy
++++ Very heavy
+++++ Extremely heavy

from the present data that the nature of the surface itself profoundly affects bacterial survival and proliferation.

Few previous studies have used the direct surface agar technique for surface sampling. Nevertheless, it appeared to be a reliable method for this investigation, and while it has been recommended as the most quantitative method for estimating microorganisms on flat, non-porous surfaces (Angelotti *et al.*, 1957), it has also permitted study of the actual dispersion of microbial populations without dislodging them.

This study indicates that further improvements in cleaning and sanitization would arise from a better understanding of the ecosystem of the food-contact surface. Relationships inferred in this investigation cannot be considered complete in themselves. Important components of the ecosystem, such as temperature, surface-pH, toxicity of surface material and atmospheric humidity, have still to be integrated into the scheme before a clear-cut picture of the "clean" surface may emerge.

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Page Charges for Publication of Research Papers

☐ Publication costs and publication pressures have increased at a fast rate over the past few years. The result is problems for all publishers, including the Institute of Food Technologists. An example of publication pressure is the considerably higher rate of receipt of research manuscripts for *Food Technology* compared with the rate of publication in the journal. One solution to this problem is the publication of special or supplemental issues at great expense to the Institute.

At the October 1967 Executive Committee meeting, the Subcommittee on Publications recognized and acknowledged the problem posed by increased costs and pressures, and discussed the matter at length. The Executive Committee then voted unanimously—as a financial expedient—to establish a page charge for research articles of $30 per page printed in either *Food Technology* or the *Journal of Food Science*.

☐ The page charge will be effective for research manuscripts received after April 1, 1968. The page charge is subject to adjustment by the Executive Committee upon recommendation of the Subcommittee on Finance after suitable experience has been gained.

The page charge SHALL NOT *constitute a bar to the acceptance of research papers for publication because an author is unable to pay the charge.*

☐ It is the view of the Executive Committee that the page charge is a matter of policy in effective administration of the journals, so long as the page charge is normal for other similar journals, it is imposed at a reasonable level, it provides for hardship cases so that it is not a barrier to publication, and it is necessary and defensible for financial reasons. At the request of the Executive Committee, concurrence of the Council Policy Committee was obtained. This publication is to serve as notice that the $30 charge per printed page will become effective for research manuscripts received after April 1, 1968. •

Influence of Various Acidities and Pasteurizing Temperatures on the Keeping Quality of Fresh-Pack Dill Pickles

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SUMMARY

A series of experiments was conducted in commercial pickle plants involving the pasteurization of fresh-pack dill pickles. The various combinations of temperature and equilibrated acidity tested spanned ranges of 120–200°F and 0.20–1.00% acetic acid. The influence of these initial conditions was determined for physical and chemical characteristics of the equilibrated brine and pickles, and supplementary data was obtained on microbial activity in the stored product. A separate experiment was carried out in which heating rates and insulation of the jar caps were investigated. Another experiment was conducted to study the influence of tightness of pack on the heating rates of brine and pickles.

Internal-product temperatures in the range of 160–170°F with an equilibrated acidity of 0.60% acetic acid or greater, prevented spoilage by natural fermentation and produced pickles of good quality. At temperatures less than 160°F, acidities of up to 1.00% acetic acid did not prevent spoilage.

Increasingly higher internal-product temperatures, from 170 through 200°F, resulted in correspondingly increased amounts of bloater damage to the internal structure of the cucumber.

Faster heating rates decreased pickle firmness, particularly for those located in the upper part of the jar. Insulation of the top of the jar cap did not protect the pickles against this loss in texture.

Tightness of pack greatly influenced the heating rate of the fresh-pack dill pickles. Here, use of the lower brine percentage (25%) resulted in failure to attain the desired internal-product temperature, while the higher brine percentage (45%) caused the internal-product temperature to rise slightly above that of the standard pack (33%). Chemical composition of the finished product was also markedly affected.

INTRODUCTION

During the past 30 years, the amount of pickling cucumbers used in producing pasteurized pickle products has increased from about 200,000 bu to nearly 9,000,000; the latter figure represents almost 40% of the current national crop. Pasteurized pickle items have greatly expanded the cucumber market by making new types of pickles available. Such products have proven very popular with the consumer because they retain much of the characteristic crispness and attractive appearance of the natural cucumber (Etchells *et al.*, 1951).

Since one of our early publications (Etchells, 1938), a number of papers dealing with various aspects of the pickle pasteurization procedure have been reported (Cook *et al.*, 1957; Nicholas *et al.*, 1957; Nicholas *et al.*, 1961a, 1961b; Pflug *et al.*, 1960) including a recommended internal-product pasteurizing temperature of 165°F for 15 min followed by prompt cooling (Etchells *et al.*, 1940; Etchells *et al.*, 1941; Etchells *et al.*, 1942, 1943, 1944a, 1944b).

Although the above procedure has been in general use for many years, there appears to have been no study conducted under commercial conditions designed to give consideration to the influence of different acidities and temperatures on the physical, chemical and microbiological changes in fresh-pack dill pickles as related to the keeping quality of the product.

EXPERIMENTAL

Temperature and acidity study. Thirteen treatments with respect to initial conditions were selected; these constituted a trial. Each treatment within a trial contained 48 jars. Three trials were made during the first season's work—the first on August 5–9 (Trial 1-G), the second on September 5–7 (Trial 2-G) in the same plant, and the third September 4–12 (Trial 1-MW) in another plant. The 15 treatments, including a duplicate and a control, and certain physical and chemical properties of the packed material are identified in Table 1. All trials were

Table 1. Identification and properties of treatments for a single trial.

Initial conditions				Cover brine		
Code	Temp.	Desired equilibrated acidity as acetic acid	Headspace	Acidity as acetic acid[1]	Salt content	pH of blended material
	°F	%	cc	%	%	
M	120	0.60	20	1.54	2.80	3.99
E	140	0.35	20	0.90	2.70	3.99
D	140	0.85	20	2.18	3.00	3.77
G	150	0.50	20	1.28	2.95	3.94
F	150	0.70	20	1.80	2.95	3.80
C	160	0.20	20	0.51	2.75	4.16
A-1	160	0.60	20	1.54	2.85	3.98
A-2	160	0.60	20	1.54	2.95	3.98
B	160	1.00	20	2.57	2.90	3.81
X	165	0.60	20	1.54	2.90	3.98
I	170	0.50	20	1.28	3.00	3.90
H	170	0.70	20	1.80	3.00	3.82
J	180	0.35	25	0.90	2.80	4.07
K	180	0.85	25	2.18	3.10	3.97
L	200	0.60	35	1.54	2.85	3.99

[1] % acetic acid × 10 = grains vinegar.

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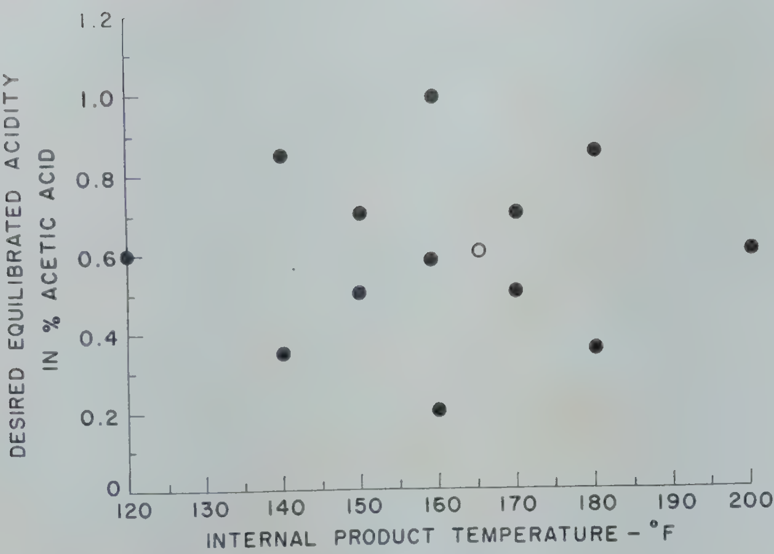

Fig. 1. Experimental plan used in the study of the influence of various acidities and pasteurizing temperatures on the quality of fresh-pack dill pickles shown in the configuration of the treatment combinations. The open circle represents the control treatment (165°F at 0.60% acetic acid).

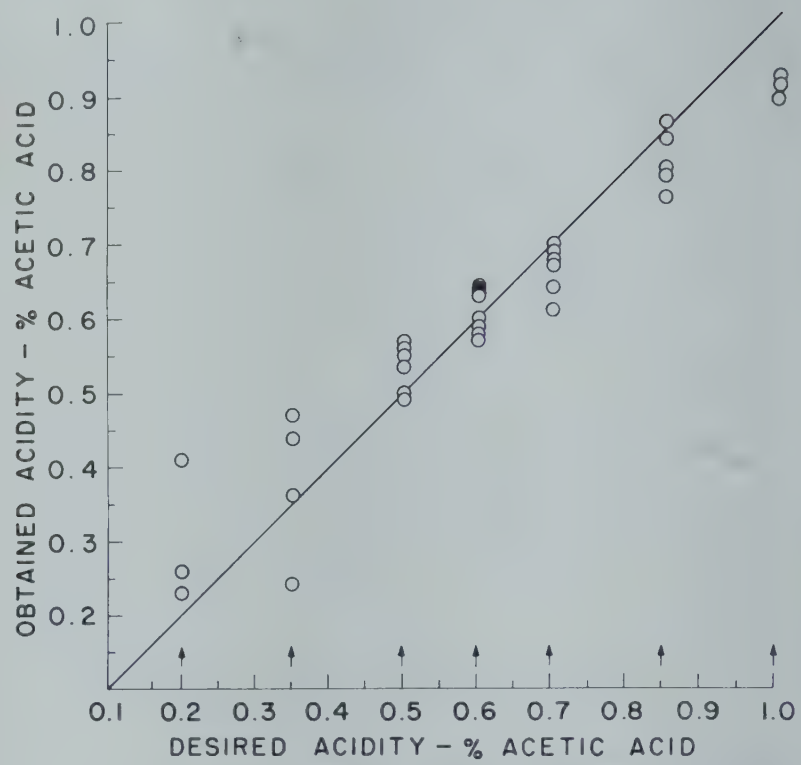

Fig. 2. Degree of success in obtaining the seven desired levels of equilibrated acidity included in the initial design of the experiment. Arrows on the abscissa mark the desired levels, and each point shown for an obtained acidity represents an average of three jars from one experimental run.

essentially the same except for the cucumber variety used. The first trial consisted of variety SMR-12 and the second of variety SR-6. The third was mixed stock of variety Maine No. 2 and another, probably SR-6. A second order statistical design was used to permit the characterization of the relationship between temperature and acidity. The configuration of the treatments in the temperature-acidity ranges is shown in Fig. 1. The extent to which the desired equilibrated acidities were achieved from the calculated brine acidities (Table 1) can be seen in Fig. 2.

Preparation of Pickles. The 32-oz. jars were first spiced with chopped dill weed and emulsified essential oil spices. Next, 10½ oz of brine, containing sufficient vinegar to equilibrate at the desired acidity levels, was poured into each of the 50 jars that constituted a run. Each jar was then hand-packed with washed, unblanched, fresh cucumbers to an accurate headspace level. All jars were packed to maintain 33% brine and 67% pickles by volume. By exercising careful control, a constant tightness of pack was obtained. One jar was blended for pH testing and another was used for temperature control. The remaining 48 jars were available for storage and future evaluation. The jars in each run were capped with 70 mm "twist-off" vacuum caps (White Cap Company, Chicago, Illinois) and pasteurized.

Pasteurizer description. This unit was designed to accommodate fifty, 32-oz jars. Two expanded-metal removable trays were employed to facilitate loading and unloading through a hinged end door. Live steam, regulated by manually operated valves, was introduced into the enclosed chamber through two manifolds located above and below the trays. Jars were cooled by a water spraying system positioned above them. Cooling water could be tempered with steam for initial cooling to prevent thermal shock.

Pasteurizer procedure. The first run contained a maximum thermometer located in the center of a cucumber and placed in the center of a jar. This thermometer checked the internal pickle temperature against the potentiometer readings. The readings were identical. Another jar was wired with five thermocouple leads to the potentiometer. The sensing ends of the leads were placed as follows:

1. Inside the center cucumber.
2. Center of the jar brine.
3. Inside the jar in the brine near the glass.
4. Pasteurizer temperature outside the jar.
5. Pasteurizer temperature outside the jar.

A four degree temperature difference was measured within individual jars during the heating process. Heat treatment refers to a given internal-product temperature without any holding time. In the pasteurizing cycle the coldest area was heated to the test temperature.

Cooling of pickles. As soon as the contents of the jars reached the desired temperature, tempered cooling water was introduced into the pasteurizer. The internal-product temperature of the jar was reduced to 100°F. The cases were stored in an area where temperature remained at approximately 70°F.

Measurements recorded on brine and pickles. Each treatment was inspected visually for signs of spoilage as indicated by turbidity of the brine.

After 6 months storage, three jars from each treatment were selected at random for analysis of brine and evaluation of the stock. In treatments which had both good and spoiled jars, three jars were selected from each kind.

On each jar the following physical measurements were taken:

1. Vacuum in inches.
2. Headspace in cubic centimeters.
3. Brine volume in ounces.
4. Refractometer readings on the brine in degrees Brix.

Chemical analyses for brine acidity (calculated as percent acetic acid), and for salt in percent were measured by the methods of Richardson *et al.* (1939). Measurement of pH was done with a glass electrode pH meter.

Microbial counts were made microscopically on the brine samples by the following methods:

1. Bacteria by smears as outlined by Wang (1941), and the Gram stain (Kopeloff *et al.,* 1928).

2. Yeasts were counted for viable and non-viable cells as described by

Table 2. Data from physical, chemical, and microscopic examination made at the end of 6 month's storage period.[1]

Trial	Temp. in °F	Desired equilibrated acidity %	Vacuum in inches	Head-space cc	Brine vol. oz	Acidity %	pH	Salt %	Spoilage %	Yeast[2] count in cells/ml	Bacterial[2] count in cells/ml
1-G	120	0.60(S)	−13.3	13	11.2	1.32	3.41	2.38	100.0	73 T	377 M
	140	0.35	4.0	48	11.0	0.47	4.03	2.45	16.7	140 T	19 T
	140	0.35(S)	−15.5	26	10.7	0.92	3.57	2.43	—	7 T	385 M
	140	0.85	5.8	42	10.9	0.86	3.78	2.68	16.7	0	65 T
	140	0.85(S)	−7.3	38	11.0	1.33	3.40	2.67	—	13 T	673 M
	150	0.50	5.5	44	10.7	0.56	4.02	1.73	4.8	0	52 T
	150	0.50(S)	2.5	44	10.7	1.02	—	1.75	—	0	>2000 M
	150	0.70	5.3	46	10.6	0.70	3.84	2.67	0.0	0	50 T
	160	0.20	5.0	45	10.9	0.41	4.25	2.53	0.0	8 T	60 T
	160	0.60	5.3	45	10.4	0.63	3.99	2.40	0.0	423 T	41 T
	160	0.60	6.5	44	10.6	0.64	4.00	2.07	0.0	206 T	75 T
	160	1.00	6.0	45	10.7	0.92	3.81	2.52	0.0	1623 T	7 T
	165	0.60	6.5	42	10.9	0.64	3.71	2.33	0.0	0	0
	170	0.50	8.5	51	10.3	0.57	3.94	2.50	0.0	12 T	32 T
	170	0.70	7.2	44	10.5	0.68	3.88	2.62	0.0	0	26 T
	180	0.35	6.9	50	10.4	0.44	4.06	2.55	0.0	8 T	140 T
	180	0.85	8.4	46	10.3	0.84	3.84	2.63	0.0	0	21 T
	200	0.60	12.3	54	10.2	0.63	3.97	2.37	0.0	266 T	63 T
2-G	120	0.60(S)	−19.3	0	11.6	1.18	3.32	2.65	100.0	163 T	368 M
	140	0.35(S)	−20.7	2	11.0	0.85	3.76	2.52	100.0	27 T	1237 M
	140	0.85	3.5	44	10.9	0.79	3.68	2.88	88.1	103 T	752 T
	140	0.85(S)	−15.3	0	11.4	1.08	3.56	2.80	—	250 T	350 M
	150	0.50	5.8	36	11.4	0.53	3.97	2.60	31.0	256 T	112 T
	150	0.50(S)	−18.7	3	10.9	0.86	3.75	2.67	—	47 T	1316 M
	150	0.70	5.5	40	11.3	0.69	3.87	2.93	42.9	80 T	656 T
	150	0.70(S)	−21.0	5	11.5	0.97	3.67	2.92	—	107 T	788 M
	160	0.20	4.5	40	11.2	0.26	4.17	2.42	0.0	0	1 M
	160	0.60	5.0	42	11.3	0.60	3.85	2.62	0.0	0	54 T
	160	0.60	5.7	40	11.8	0.57	3.94	2.62	0.0	120 T	9 T
	160	1.00	5.3	43	10.9	0.92	3.71	2.77	0.0	0	22 T
	170	0.50	6.0	40	11.2	0.55	3.92	2.70	0.0	0	97 T
	170	0.70	7.7	43	11.4	0.67	3.90	2.93	0.0	35 T	127 T
	180	0.35	7.6	43	11.3	0.36	4.04	2.60	0.0	0	106 T
	180	0.85	7.2	45	11.1	0.80	3.76	2.87	0.0	0	60 T
	200	0.60	11.5	57	10.8	0.58	3.91	2.63	0.0	0	97 T
1-MW	120	0.60(S)	−0.7	50	8.2	1.16	3.14	2.56	96.0	63 T	453 M
	140	0.35(S)	−7.3	51	10.7	0.90	3.49	1.90	100.0	27 T	3398 M
	140	0.85(S)	−5.7	31	10.5	1.69	3.14	3.03	100.0	28 T	1110 M
	150	0.50	7.8	47	10.1	0.50	3.89	0.92	13.0	0	22 T
	150	0.50(S)	2.8	72	8.9	0.49	3.97	2.20	—	15 M	36 M
	150	0.70	5.8	46	10.3	0.64	3.81	2.52	47.0	0	11 T
	150	0.70(S)	−2.0	68	8.2	1.15	3.39	2.32	—	47 T	1688 M
	160	0.20	8.7	55	9.3	0.23	4.33	1.50	45.5	3 T	90 T
	160	0.20(S)	3.7	57	9.2	0.53	3.78	1.50	—	60 T	750 M
	160	0.60	7.7	50	10.0	0.59	3.73	2.92	0.0	3 T	6 T
	160	1.00	7.8	49	10.0	0.89	3.66	2.65	0.0	236 T	14 T
	170	0.70	11.8	55	10.5	0.61	3.71	2.95	0.0	0	17 T
	180	0.35	10.7	73	9.9	0.24	4.28	1.62	4.2	0	22 T
	180	0.70	11.2	61	9.4	0.76	3.77	2.15	0.0	0	22 T
	180	0.85	16.2	66	10.3	0.87	3.62	2.55	0.0	0	0
	185	0.50	14.7	69	9.4	0.49	3.95	0.60	0.0	3 T	11 T
	200	0.60	18.8	83	7.8	0.64	3.54	2.47	0.0	0	442 T

[1] Data are for means of three jars. Lots showing spoilage shown as (S).
[2] T = Thousands, M = Millions.

Mills (1941).

Pickles from the three jars in each sample were pooled in a single lot and firmness determined with the USDA Fruit Pressure Tester (Magness *et al.*, 1925) using the procedure of Bell *et al.* (1955).

All pickles in each sample were cut and examined for evidence of bloating and other internal defects. Bloaters were classified as "balloon" or "lens" and reported as total bloaters (Etchells *et al.*, 1951).

An unusual condition associated only with high temperature treatments was observed. Here, the skin portion of the pickle separated from the fleshy part leaving thin, longitudinal cavity; this defect was recorded as a "skin split" (Fig. 3).

Additional samples were selected and analyzed for peroxidase and polyphenoloxidase activity in brine and pickles (Aurand *et al.*, 1956; Sisler *et al.*, 1958).

Heating rates. In a separate experiment, three rates of attaining a predetermined level of internal-product temperature were used 15 min, 30 min and 45 min. At the 15 min rate an additional treatment was included in which a pad of ¼ in. insulating cork was cemented to the top of the cap to protect the top pickles. The test temperature was 165°F with no holding period and 0.60% acetic acid was used. Twelve jars of each treatment were prepared and all other conditions of treatment were the same as used in the other experiments. Pressure tests were made separately on pickles from the top and bottom halves of four jars from each treatment.

Tightness of pack. In this experiment three different degrees of tightness of pack were specified. The tight pack (Treatment A) had 25% brine and 75% pickles; the standard pack (Treatment B) had 33% brine and 67% pickles; the loose pack (Treatment C) had 45% brine and 55% pickles.

RESULTS AND DISCUSSION

Temperature and acidity experiments. The measurements made at each trial are recorded in Tables 2 and 3. The reproducibility of the physical and chemical measurements, expressed as coefficients of variation, are shown in Table 4. While these coefficients

Fig. 3. Examples of undesirable changes in internal cucumber structure and appearance, classified as bloater damage, observed in unfermented, fresh-pack dill pickles pasteurized at temperatures of 170–200°F. The four types of bloater formation appear in the four columns of sliced pickles as follows (left to right): First column, balloon-type bloaters; second column, mostly lens-type bloaters; third column, skin-split-type bloaters; and, fourth column, honeycomb-type bloaters. Top row of pickles are free of bloater damage. Bloater damage similar to that illustrated above, has been reported earlier (Nagel and Vaughn, 1954; Nicholas and Pflug, 1962).

varied somewhat from trial to trial, only the vacuum measurements were sufficiently variable to cast doubt on the efficiency of the three jar sample as representative on an entire treatment. The subsequent statistical analyses used the average of three jars.

A quadratic regression equation was fitted to each of the response variables where the independent variables were the initial conditions of pasteurizing temperature and the desired equilibrated acidity. A prediction equation was obtained for each response variable on each trial. Ability to predict response from the initial conditions is measured by the coefficient of determination given in Table 5. It must be emphasized that in computing the regression equation only the data from unspoiled jars were used unless the spoilage was 100% in that treatment. This procedure was adopted on the grounds that what was wanted was the effect of initial conditions on the jar contents apart from spoilage *unless* the condition was sure to lead to spoilage.

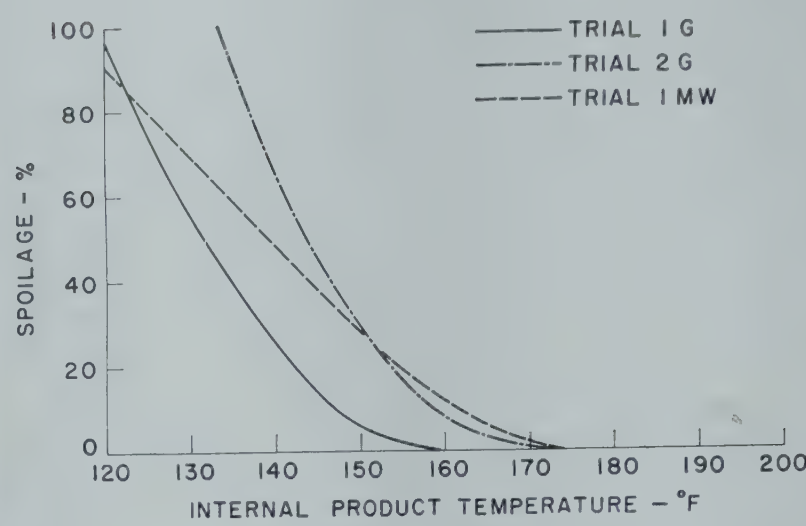

Fig. 4. Predicted spoilage of fresh-pack dill pickles(after six months' storage) as a function of pasteurizing temperature with an initial equilibrated acidity of 0.60% acetic acid.

Table 3. Data from pickle stock. Examinations made after 6 months storage.[1]

Initial conditions		Trial 1-G			Trial 2-G			Trial 1-MW		
Temperature, °F	Desired equilibrated acidity as % acetic acid	Mean, pressure test, lbs	Mean, total bloaters %	Mean, "skin splits" %	Mean, pressure test, lbs	Mean, total bloaters %	Mean, "skin splits" %	Mean, pressure test, lbs	Mean, total bloaters %	Mean, "skin splits" %
120	0.60(S)	14.8	86.4	0	16.0	73.6	0	15.4	0	0
140	0.35	16.8	0	0	—	—	—	—	—	—
140	0.35(S)	15.3	48.6	0	15.5	96.7	0	16.5	57.8	—
140	0.85	15.8	0	0	13.1	0	0	—	—	—
140	0.85(S)	15.3	0	0	15.1	67.5	0	15.7	28.5	0
150	0.50	14.3	0	0	15.8	0	0	15.3	0	0
150	0.50(S)	15.1	0	0	15.5	76.9	0	17.6	27.0	0
150	0.70	15.0	0	0	17.0	5.0	0	16.5	0	0
150	0.70(S)	—	—	—	15.6	87.1	0	16.4	16.6	0
160	0.20	15.0	0	0	15.9	0	0	16.2	0	0
160	0.20(S)	—	—	—	—	—	—	16.6	16.2	0
160	0.60	13.5	2.6	0	17.1	0	0	15.8	0	0
160	0.60	15.6	0	0	16.6	0	0	—	—	—
160	1.00	14.0	0	20.5	16.1	0	0	15.7	0	0
165	0.60	13.9	0	0	—	—	—	—	—	—
170	0.50	12.9	0	2.3	16.9	0	0	—	—	—
170	0.70	14.2	6.2	9.3	16.0	11.1	0	14.2	0	9.1
180	0.35	14.3	19.2	0	15.4	0	13.8	13.9	31.0	0
180	0.70	—	—	—	—	—	—	15.6	7.6	5.1
180	0.85	13.3	0	35.1	16.4	0	13.5	11.6	29.6	7.4
185	0.50	—	—	—	—	—	—	13.6	0	11.7
200	0.60	10.8	0	20.5	13.0	0	69.5	13.1	91.6	0

[1] Lots having spoilage shown as (S).

Table 4. Reproducibility of physical and chemical determinations from jar to jar in the same lot (coefficient of variation expressed in percent of normal values).

Trial	Vacuum in inches	Headspace in cc	Brine vol, oz	Acidity %	pH	Salt %
1-G	32	7	3	7	1	4
2-G	19	9	2	3	2	3
1-MW	27	16	8	8	3	8

Table 5 shows that consistent predictions were obtained for vacuum, headspace, acidity, pH, spoilage, and total bacteria. For the other response variables at least one of the three trials showed no appreciable relationship to initial conditions. In the case of the refractometer readings there was so little variability in the response that the data were not presented.

The effects of temperature on spoilage are plotted in Fig. 4, again assuming an initial equilibrated acidity of 0.60%. These results are consistent with our previous commercial recommendations that the internal-product temperature should be 165°F with a 15 min holding period) with an equilibrated acidity sufficient to maintain a brine pH of 4.0 and below to assure protection from spoilage.

The results of the analyses for enzyme activity of the two oxidative enzyme systems can be summarized as follows: (1) all samples analyzed were negative for polyphenoloxidase activity; (2) peroxidase activities were highly variable below 180°F and absent above that temperature.

The discovery of skin-splits in the

Table 5. Predictability of final measurements (Y) from initial conditions of pasteurization temperature (X_1) and equilibrated finished acid strength (X_2) (expressed as % variability explainable by initial conditions).[1]

Trial	Vacuum in inches	Head-space cc	Brine vol, oz	Acidity %	pH	Salt %	Spoilage %	Yeast count per ml	Bacterial count per ml	Pressure test in lbs	Bloaters in %	Skin splits in %
1-G	79	71	84	86	79	23	93	11	75	74	56	95
2-G	86	87	33	92	88	73	82	67	68	49	76	93
1-MW	78	90	63	73	79	41	77	76	74	53	24	45

[1] The prediction equation has the form

$$y = b_0 + b_1X_1 + b_2X_2 + b_3X_1^2 + b_4X_2^2 + b_5X_1X_2$$

where $X_1 = (\text{Temperature} - 160°)/5$, $X_2 = 2\ (\text{Acidity} - 6.0\ \text{gr.})$, and the b's are constants calculated from the data. There is a separate set of b's for each Final Measurement (Y) and for each trial making 36 sets in all.

Table 6. Comparison of good (G) and spoiled (S) jars in lots of partial spoilage. Pressure tests and % bloaters measured on the pickle stock.

Trial	Initial conditions		Vac. in inches	Head-space in cc	Brine oz	Acidity %	pH	Salt %	Yeast[1] count in cells/ml	Bacterial[1] count in cells/ml	Pressure test in lbs	Bloaters %
	140°F	G	5.8	42.3	10.9	0.86	3.78	2.68	0	65 T	15.8	0
	0.85%[2]	S	−7.3	38.3	11.0	1.33	3.39	2.66	13 T	673 M	15.3	0
1-G	140°F	G	4.0	47.7	11.0	0.47	4.03	2.45	140 T	19 T	16.8	0
	0.35%	S	−15.0	26.0	10.7	0.92	3.57	2.43	7 T	385 M	15.3	49
	150°F	G	5.5	44.0	10.7	0.56	4.02	1.73	0	52 T	14.3	0
	0.50%	S	2.5	44.0	10.7	1.02	—	1.75	0	>2000 M	15.1	0
	140°F	G	3.5	44.0	10.9	0.79	3.68	2.88	103 T	752 T	13.1	0
	0.85%	S	−15.3	0.0	11.4	1.03	3.56	2.80	250 T	350 M	15.1	68
2-G	150°F	G	5.5	40.3	11.3	0.69	3.87	2.93	80 T	656 T	17.0	5
	0.70%	S	−21.0	4.7	11.5	0.97	3.67	2.92	106 T	788 M	15.6	87
	150°F	G	5.8	36.0	11.4	0.53	3.97	2.60	257 T	112 T	15.8	0
	0.50%	S	−18.7	3.0	10.9	0.86	3.75	2.67	47 T	1316 M	15.5	77
	160°F	G	8.7	54.7	9.3	0.23	4.33	1.50	3 T	90 T	16.2	0
	0.20%	S	3.7	56.7	9.2	0.53	3.78	1.50	60 T	750 M	16.6	16
1-MW	150°F	G	5.8	46.3	10.3	0.64	3.81	2.52	0	11 T	16.5	0
	0.70%	S	−2.0	67.9	8.2	1.15	3.39	2.32	47 T	1688 M	16.4	17
	150°F	G	7.8	47.0	10.1	0.50	3.89	0.92	0	22 T	15.3	0
	0.50%	S	2.8	72.3	8.9	0.49	3.97	2.20	15 M	36 M	17.6	27
	Average											
	Good		5.82	44.70	10.66	0.59	3.93	2.41	64 T	198 T	15.64	0.6
	Spoiled		−7.81	34.76	10.28	0.92	3.64	2.31	1725 T	887 M	15.83	37.9
	Difference		13.63	9.94	0.38	0.33	0.29	0.10	27:1	4480:1	0.19	37.3

[1] T = Thousands, M = Millions.
[2] Refers to desired equilibrated acidity as acetic acid.

pickles pasteurized at the higher temperatures was regarded as an unusual finding. The skin-split averages, plotted against temperature in Fig. 5, show a striking increase with increased pasteurization temperature. Examples of four different kinds of bloater damage at temperatures above 170°F are shown in Fig. 3.

Perhaps the most noticeable factor in all these results is the effect of spoilage in the jar. Direct comparisons between averages of the several response variables for both good and spoiled jars are shown in Table 6. These differences vary somewhat from trial to trial but worth noting are: loss in vacuum, marked increase in acidity (and lowering of pH), sharp increase in total bacteria, a moderate increase in yeasts, and a marked increase in the percentage of bloaters.

Heating rates. The relevant results of the evaluation made on the material from this experiment after 6 months' storage are presented in Fig. 6. There was no spoilage in any of the treatments.

The pickles in the bottom portion of the jars averaged 1.5 lb higher in pres-

Table 7. Studies on the influence of tightness of pack on the heating rate of fresh-pack dill pickles: Chemical and physical properties of the three experimental packs.[1]

Treatment		Final brine acidity	Final salt content	Pickles per jar
no.	% brine	%	%	number
A	25	0.60	1.90	15
B	33	0.73	2.75	13.5
C	45	1.05	3.75	11.5

[1] The pickles were first salt-brine blanched and then covered with a hot brine (140°F) having an acid content of 19.5 grains vinegar (= 1.95% acetic acid) and 7.2% salt.

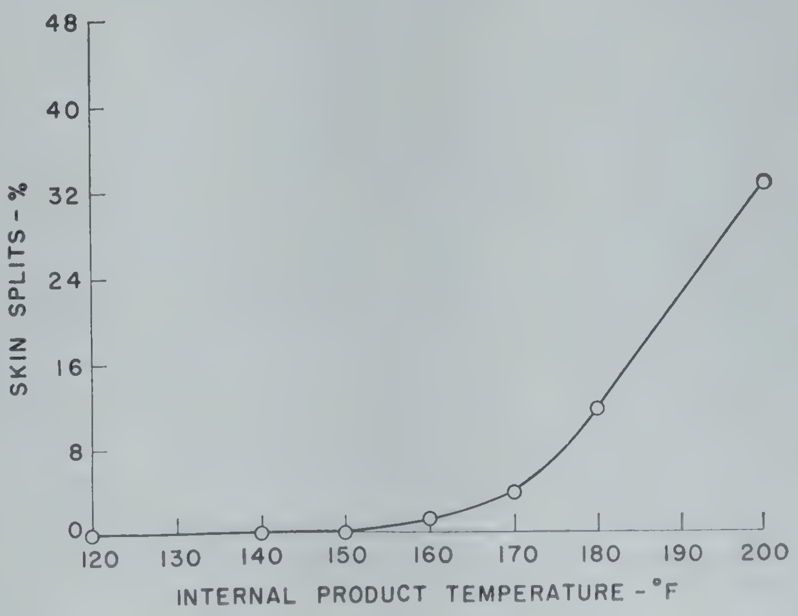

Fig. 5. Effect of pasteurizing temperature on the formation of skin-splits in fresh-pack dill pickles. The number of pickles cut to determine the percentage values shown ranged from 110 pickles for the 120°F treatment to 479 for 160°F.

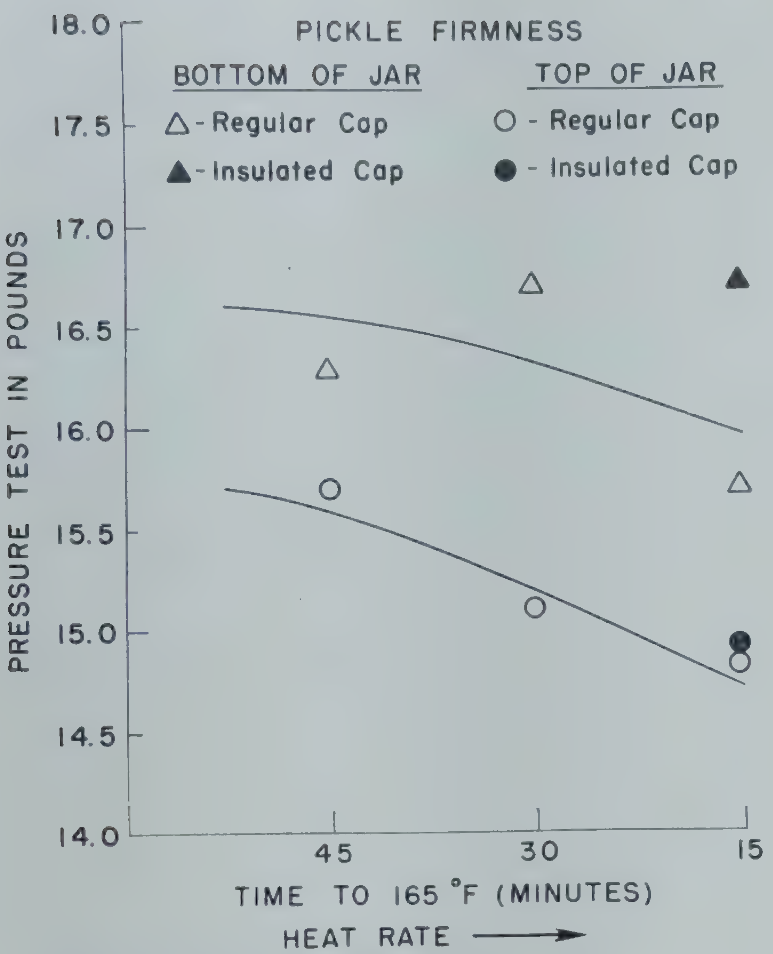

Fig. 6. Effect of rate of heating on the firmness of fresh-pack dill pickles according to location in the jar and, as influenced by insulation of the jar cap. Each point shown represents the average firmness of 20 pickles.

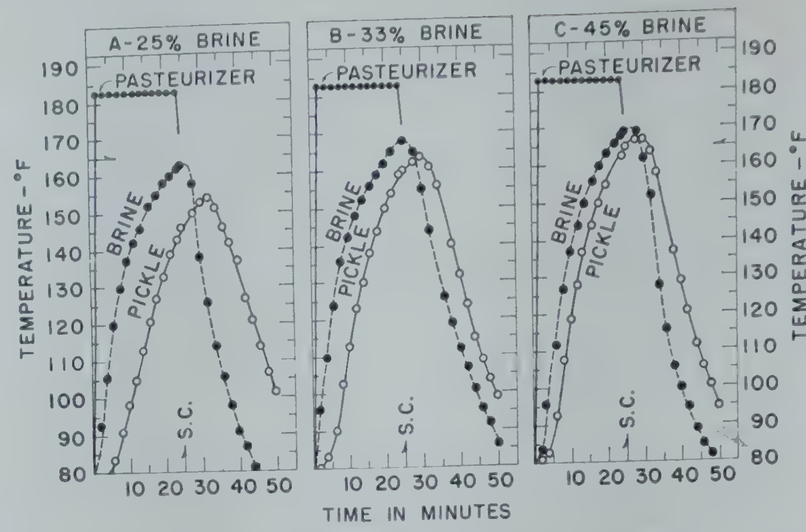

Fig. 7. Influence of tight and loose packs, compared with a standard pack, on the rate of heating of fresh-pack dill pickles. Treatment A (tight) refers to 25% brine and 75% pickles by volume; Treatment B (the standard), 33% brine and 67% pickles; Treatment C (loose), 45% brine and 55% pickles. The standard pack was heated to 165°F internal-product temperature and promptly cooled. The start of cooling (S.C.) began after 25 minutes of heating for all treatments.

sure test than those in the top portion. The faster rate of heating produced softer pickles and the difference between the top and bottom pickles was essentially the same for all three heating rates. The statistical analysis indicated that the difference between top and bottom pickles for the insulated cap treatment was not sufficiently larger than the same difference in uninsulated jars to be judged significant at the conventional 5% level. However, the analysis suggests that the insulated cap may afford some protection against thermal softening in the bottom portion of the jar.

Tightness of pack. The results of this experiment are summarized in Table 7 and Fig. 7. It is clear that the tight pack (75% pickles) results in underheating with respect to internal-product temperature whereas the looser pack (55% pickles) results in overshooting of the desired internal-product temperature. These results suggest that deviations from the standard pack in the direction of a tighter one would increase the probability of underheating and the likelihood of spoilage. A looser pack would be adequately preserved but the final levels of acidity, salt content, and spicing would be increased to the undesirable range for good product flavor.

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Discoloration of Egg Albumen in Hard-Cooked Eggs

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SUMMARY

Eggs, 1 day old and 1 week old, were cooked in boiling water for 12 min, then held in water at 60, 70 and 80°C for time periods up to 25 hr. A Gardner Color Difference Meter was used for color determinations.

Results show that the higher the holding temperature following cooking, the greater is the discoloration. Time of storage is also a factor—the longer eggs are held, the greater is the discoloration. Eggs stored for 1 week at room temperature before cooking are more vulnerable to the discoloration than fresh eggs.

A study was made on the nature of the discoloration. It was found that the color is due to "browning reaction" (carbonyl amine). This is not surprising since egg albumen which is high in protein contains a small amount of the reducing sugar glucose. When the glucose in the egg albumen was removed enzymatically and the resulting product was cooked in a polyethylene pouch, no discoloration occurred.

A practical application in preventing the brown discoloration of hard-cooked eggs is to use fresh eggs and cool them immediately following cooking.

INTRODUCTION

Hotel and restaurant chefs as well as housewives occasionally observe that albumen in hard-cooked eggs turns a caramel-brown color following cooking. This condition is alarming to cooks and they often feel that something was wrong with the eggs before they were cooked.

After some investigation it was discovered that holding eggs at an elevated temperature following cooking results in a caramel-colored albumen. It seemed logical that this discoloration was the Maillard reaction since egg albumen contains both amines and glucose. This experiment was undertaken to study various factors that influence the onset of off-color and to determine its cause.

It has been known since the early forties that the brownish off-colors and accompanying off-odors in stored dried egg albumen were due to the Maillard (glucose-amine) reaction, and that these could be lessened or prevented by the removal of glucose. More recently, the same reaction has been found to be the cause of browning in the canning of hard-cooked eggs (Trelease *et al.,* 1952; Takasaki *et al.,* 1954). The browning could be lessened or prevented by lowering the pH of the cooked egg with an organic acid or an acidic buffer. In general, factors that have been found to favor the rate of formation of the brown end-products of the Maillard reaction, according to Olcott *et al.* (1945) and Reynolds (1963) include: (1) increasing temperature (2) increasing alkalinity and (3) increasing concentration.

EXPERIMENTAL

Treatment of eggs. *Age.* One-day-old large eggs stored at 13°C were procured from one strain of White Leghorns from the Cornell University Poultry Farm. Half of the eggs were cooked on the day of receipt, the other half were stored at room temperature (22°C) in molded fiberboard egg cartons for 1 week.

Holding times and temperatures. Two dozen eggs per lot were tied in a cheesecloth bag, lowered into a kettle of boiling water and boiled gently for 12 min. The bags were then transferred from the cooking water to a water bath preset for the desired temperature (60, 70, or 80°C) and held for the desired time (0, 5, 15 or 25 hr). One dozen of the eggs were then cooled in slush ice for 1 hr and the remaining dozen were placed in molded fiberboard cartons without cooling and held at room temperature for 24 hr.

Color determinations. The color of the egg albumen was determined by the use of the Gardner Color Difference Meter, Model AC-2A, using as a standard a white plate reading: $R_d = 88.8$, $a = -1.3$, and $b = +3.2$. Only the R_d readings will be shown in this paper because they are the most meaningful. Since the aperture was too large for the sample, it was reduced by covering it with an acetate square sprayed flat black except for a hole 2 cm in diameter in the center. During the reading a cover was placed over the samples to prevent leakage of light. Before reading, the eggs were peeled and a slice was removed from the small end. The remainder of the egg was then set in position over the aperture. The samples were also graded visually for color development by one person at the time they were read on the Color Difference Meter. A scale of 0 (no color development) to ++++ (extreme color development) was used.

One week later the entire experiment was repeated using the eggs which had been stored at room temperature.

Glucose removal. After separating the whites from the yolks of a number of day old eggs, the whites were thoroughly mixed. Glucose was removed from a quantity of this albumen by the use of glucose oxidase to discover if its absence would eliminate the discoloration. After acidifying with citric

Table 1. Analysis of variance for color scores for cooked egg albumen.

Source of variation	df	Mean squares R_d
Age [1]	1	22921.90**
Holding temperature [2]	2	3764.27**
Holding time [3]	3	2799.38**
Storage time [4]	1	55.49**
Age × Holding temperature	2	513.01**
Age × Holding time	3	107.77**
Age × Storage time	1	159.16**
Holding temperature × Holding time	6	1000.76**
Holding temperature × Storage time	2	5.95
Holding time × Storage time	3	36.23**
Error	432	5.60
Total	479	

** $P<.01$.
[1] Ages—1-day-old eggs vs. 1-week-old eggs.
[2] Holding temperatures—60, 70, and 80°C.
[3] Holding times—0, 5, 15, and 25 hr.
[4] Storage times—1 hr and 1 day.

acid to pH 7.1 hydrogen peroxide (30%) was added with slow agitation. The enzyme was then added and the slow agitation (approximately 30 rpm) continued until there was no longer evidence of foam build-up. Hydrogen peroxide was then dripped in decreasing amounts until the reaction was complete and the albumen essentially glucose free. About 15 hr were required.

The desugared albumen was poured into polypropylene pouches (4.1 cm in diameter) in 50 g portions, then clipped shut. Untreated albumen from the same batch was then poured into similar pouches in the same manner. The pouches were cooked in boiling water for 12 min then transferred to a water bath preset at 80°C and held for 25 hr for maximum color development. All samples were cooled in slush ice, then the color was determined on the Color Difference Meter as previously described.

pH adjustment. Albumen was separated from the yolks of 1-day-old eggs and thoroughly blended. Two hundred ml aliquots were adjusted from pH 6.0 to pH 10.0 in 0.5 pH units using either concentrated citric acid or $1N$ sodium hydroxide. The initial pH of this albumen was 8.0. The albumen was placed into polypropylene pouches using approximately 50 ml per pouch. The filled pouches were sealed and cooked in boiling water for 12 min, then transferred to an 80°C water bath for 25 hr. After cooling in slush ice for 1 hr, the samples were read on the Gardner Color Difference Meter.

Eggs which had been procured 2 and 3 days earlier from the same strain of hens and stored at room temperature were treated in the same manner at the same time, the initial pH being 8.45 and 8.70, respectively.

Taste-paneling. In an attempt to ascertain whether the reaction produced a flavor change along with the color, coded samples of cooked egg albumen held at 80°C for 5, 15 and 25 hr, were presented to a taste panel of 4 judges. A multiple comparison test was used with a scale from 0 (not different from reference sample) to 5 (extremely different from reference sample), the reference sample being freshly cooked egg albumen. As a control, a sample of freshly cooked albumen was also included in the test samples. Red lighting was used to eliminate the color differences that occurred among the sample. The panel was asked to judge flavor only. The test was run in duplicate.

Statistical analysis. The data was analyzed by analysis of variance using a Control Data 1604 Computer. Significant differences among the mean scores were determined by using Duncan's New Multiple Range Test (Steel *et al.*, 1960).

RESULTS

Analysis of variance was run on the causes of discoloration of the cooked egg albumen. The results are shown in Table 1. It can be seen that age of eggs, holding temperature, holding time before color determination and storage time were all significant at the 1.0% level. Interactions between age and holding temperature, age and holding time, age and storage time, holding temperature and holding time, and holding time versus storage time were also significant at the 1.0% level (Table 1).

Effect of age of egg. The ages of of the eggs used were 1 day and 1 week. The older the eggs, the sooner the discoloration became apparent. For example, in 1 day old eggs cooled promptly, no visible color change was noticed even when the eggs had been stored at 60°C for as long as 24 hr (Table 2).

In the 1 week old eggs cooled promptly, however, the color change was visible and significantly different at 15 hr with a temperature of 60°C. Since the pH of the albumen of the fresh eggs was 8.0 and that of the week old egg 9.15, it was assumed that the higher pH of the older eggs was the cause of the greater degree of brown color in the albumen of these eggs with a comparative holding time and temperature.

Effect of holding temperature. Holding temperatures used were 60, 70 and 80°C. In Table 2, it can be seen that significantly less color developed, as evidenced by the higher R_d values, when the eggs were held at 60°C than at 80°C regardless of other factors involved such as the age of the egg or storage time. This indicates that heat catalyzes the reaction and this agrees with Reynolds (1963) who observed that the rate of browning increased rapidly with increased temperatures. Not only did more color develop at the higher holding temperature, but it developed faster indicating a time-

Table 2. Effect of holding temperature and time on the color of cooked egg albumen.

Holding temperature C	Holding time hr	1-day-old eggs: Cooled 1 hr Visual	1-day-old eggs: Cooled 1 hr R_d	1-day-old eggs: Cooled 24 hr Visual	1-day-old eggs: Cooled 24 hr R_d	1-week-old eggs: Cooled 1 hr Visual	1-week-old eggs: Cooled 1 hr R_d	1-week-old eggs: Cooled 24 hr Visual	1-week-old eggs: Cooled 24 hr R_d
60°	0	0	78.0^{a}	0	75.6^{ab}	0	65.7^{b}	0	64.9^{ab}
	5	0	75.9^{bc}	0	76.7^{a}	0	68.9^{a}	+	64.2^{b}
	15	0	73.6^{d}	0	75.6^{ab}	+	62.7^{e}	+	67.0^{a}
	25	0	75.8^{bc}	+	70.6^{c}	+	64.3^{b}	+	66.0^{ab}
70°	0	0	77.2^{ab}	0	75.8^{ab}	0	64.1^{bc}	0	66.2^{ab}
	5	0	77.4^{ab}	0	75.7^{ab}	0	58.3^{de}	+	60.7^{c}
	15	0	74.3^{cd}	+	73.5^{b}	+	59.4^{d}	++	55.8^{d}
	25	0	78.6^{a}	+++	71.0^{c}	++	51.0^{f}	+++	53.2^{d}
80°	0	0	78.1^{a}	0	76.6^{a}	0	67.8^{a}	+	66.9^{a}
	5	+	74.0^{cd}	+	74.7^{ab}	+	57.6^{e}	++	59.4^{c}
	15	++	63.9^{e}	+++	61.0^{d}	+++	45.2^{g}	+++	47.8^{e}
	25	++++	58.7^{f}	++++	56.3^{e}	++++	42.4^{h}	++++	40.9^{f}

Means in a column with the same superscript are not significantly different according to Duncan's New Multiple Range Test ($P<.05$). Each mean is an average of 10 readings.

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Table 3. Color changes in normal and stabilized egg albumen.

Holding time	Visual score	R_d
Normal		
0 hr	0	74.0
25 hr	++++	50.9
Stabilized		
0 hr	0	76.1
25 hr	0	71.0

Table 4. Effect of pH on the color of cooked egg albumen.

	R_d Values Age of Eggs		
pH	Fresh	2 days	3 days
6.0	67.4	67.8	68.1
6.5	67.8	67.7	65.2
7.0	62.5	63.3	62.0
7.5	60.6	59.8	62.1
8.0	56.3	56.1	55.9
8.5	52.5	54.5	52.4
9.0	48.6	42.9	42.8
9.5	30.5	22.5	29.6
10.0	18.1	15.5	11.2

Albumen was cooked after adjustment, then held at 80°C for 25 hr.
Each value is an average of 4 readings.

Table 5. Taste panel scores (eggs held at 80° for 0, 5, 15 and 25 hr).

Holding time (hr)	Average score
0 (control)	0.25
5	1.13
15	2.38
25	3.50

Scale:
0 = no difference from standard.
5 = extremely different from standard.
Each value is the mean of 8 judgments.

temperature interaction.

Length of holding time. The length of holding times in the water bath were 0, 5, 15 and 25 hr. As can be expected, the longer the time the eggs were held at elevated temperatures, regardless of the temperature, the more color, and these differences were highly significant. The only exception to this is the case of fresh eggs promptly cooled and held at 60°C and 70°C (Table 2). In these two instances, the eggs held at 15 hr showed significantly more color according to the R_d values although they were not visibly darker. Eggs from the same lot held at 70°C for 25 hr showed no significantly greater color than the controls. This is probably due to inherent color differences in the egg albumen. In all other cases as the length of time that eggs were held in the water bath was increased, the more intense was the color.

Effect of storage time. Storage time refers to the time the eggs were held after cooking and before color determinations were made (cooled 1 hr in slush ice versus held 24 hr at room temperature). In Table 2, it can be seen that when the eggs were held for 24 hr they were darker in all cases than eggs cooled in slush ice for 1 hr before reading.

Effect of glucose removal. It is evident from Table 3 that the albumen treated to remove the glucose (even after 25 hr of holding at 80°C) showed no visible color development and little change in the R_d values. The untreated controls, however, showed a great deal of color development with a drop of nearly 50% in the R_d readings. This indicates that the brown color which develops must indeed be the end result of the glucose-amine browning reaction (Maillard reaction). Analysis of variance shows that both treatment and holding times are highly significant. There also is a highly significant interaction which points out that color development is dependent on both time and presence of glucose.

Effect of pH adjustment. As the pH of the albumen was increased the amount of color increased as can be seen in Table 4. This is based on R_d values of albumen adjusted to the various pH values and then cooked and held at 80°C for 25 hr. The R_d values appear to decrease slowly as the pH goes up to 8.5 then drop rapidly.

Taste panel evaluation. When the albumen of eggs held at 80°C for extended periods of time was compared to that of freshly cooked eggs (Table 5), the heated egg albumen had developed a definite off-flavor, which was described as bitter by some of the judges. The amount of off-flavor increased with increased holding time.

DISCUSSION

The Gardner Color Difference Meter divides visual color into 3 dimensions: light to dark, the R_d readings; red (+) to green (−), the a readings; and yellow (+) to blue (−), the b readings. Freshly cooked albumen from fresh eggs appears to have a light greenish-yellow color as evidenced by high R_d; low − a and low + b readings. A typical fresh egg reading is R_d 781, a − 5.4, and b + 8.7.

As the color develops in the overheated albumen it becomes darker (lower R_d), redder (a reading changing from green [−] to red [+] and more yellow (higher +b readings). A typical reading for eggs judged visually as ++++ is R_d 40.9, a +2.4 and b +12.6. The total effect of these changes is a brownish-caramel color. The albumen of even freshly cooked old eggs is darker and has a slightly greener appearance. For example, R_d 63.7, a −9.1 and b +7.4 is a typical older egg reading. The darkening occurs with considerably more speed and to a greater extent in older eggs than fresh eggs. An examination of the effect of pH changes in albumen (Table 5) indicates that the higher pH of the old eggs is the cause of the faster development of these pigments.

High holding temperatures and long times are also factors in the development of off-colors as is the lack of prompt cooling. Holding cooked eggs in hot water for service is a poor practice also from the standpoint of the greening of the yolks that accompanies the discoloration of the albumen. This greening occurs even before there is evidence of color changes in the white.

Taste panel results indicate that flavor changes occur with the color changes, which becomes more apparent as the eggs are held at elevated temperatures. A flavor change has also been found to occur concurrently with color changes in the case of dried eggs.

Since the results of holding albumen from which the glucose has been enzymatically removed for the longest time and at the highest temperature used showed essentially no color changes, it is apparent that the brown color is due to the melanoidins which are the end-products of the Maillard reaction. Prompt cooling of the eggs following cooking will prevent this brown discoloration of the albumen. Rapid cooling is commonly recommended for the prevention of the greening caused by the formation of ferrous sulfide on the surface of the yolk.

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Differentiation between Varieties of Bush Snap Beans by Chemical and Physical Methods

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SUMMARY

Ten varieties and selections of snap beans were chosen to represent regular and Blue Lake types for comparing the differences in carbohydrates at four stages of maturity. The regular bush types were higher in total sugars and starch than Blue Lake types in all sizes. Also, changes in these constituents with maturation were greater in the regular bush types. There were larger quantities of water-soluble pectin in Blue Lake types after canning. Calgon-soluble pectin and cellulose increased more rapidly with an increase in sieve size in regular bush types when analyzed fresh, but less rapidly in protopectin. Sloughing increased with sieve size in canned Blue Lake type beans while it decreased in the large sieve regular bush type.

INTRODUCTION

The differences between carbohydrates of varieties and selections of snap beans appear to offer possibilities for selection of types that possess higher quality characteristics. Control of snap bean maturity for processing has been one of the major problems in the food industry because of wide differences in the percentage of seed vs fiber in varieties. Also, there are significant differences in sieve size distribution between varieties at the same stage of physiological maturity, even under the same environmental conditions. A knowledge of the chemical and physical characteristics of different types of snap beans should be helpful in choosing the correct variety for a particular processing method.

It has been shown that the percentages of fiber and seed of snap beans increase with maturity, and vary greatly with variety (Gould, 1951; Guyer *et al.*, 1952). Culpepper (1936) found that the chemical composition of snap beans changes rapidly with maturation. Sugar content in the seed is largely sucrose, which decreases rapidly after the 15th day from flowering. Gould (1951) found there is an increase in alcohol-soluble solids, total solids, easily hydrolyzable reserve polysaccharides, cellulose and nitrogen in canned and frozen snap beans with an increase in maturity. It has also been demonstrated that there is an increase of cellulose in the seed of snap beans during storage, and a cellulose decrease in the pods (Sistrunk, 1965a; Parker *et al.*, 1935). The change in cellulose solubility of total pods actually decreased in Earligreen variety but increased in Gallatin 50, indicating a more rapid senescence in Earligreen (Sistrunk, 1965b). Definition of quality differences among varieties of bush snap beans has been a controversial subject since the advent of Blue Lake bush types. The purpose of this study was to determine the carbohydrates of a number of varieties and selections, representing Blue Lake and regular bush types, in order to more clearly distinguish between the two for the benefit of the plant breeder and the processor.

MATERIALS AND METHODS

Beans were grown in a garden plot at Fayetteville, Arkansas, in 1966, under uniform conditions with regular irrigation. The varieties and selections studied were Gallatin Valley 50, Tenderette, Trugreen, Kentucky Wonder, XP-274 and Oregon State University selections 949, 8224, 8353, 9155M and 9827. Harvesting was kept as comparable as possible by daily observations of sieve size of pods. Pods were harvested when there were two 6 sieve pods/ft of 40 ft rows in order to obtain sufficient 6 sieve pods. In most instances, pods were predominantly 4 and 5 sieve with a lesser percentage of 3 sieve. The beans were harvested by hand and separated into sieve sizes 3, 4, 5 and 6 with the aid of a hand-sizing device. The size of Kentucky Wonder was estimated by width and diameter. A sub-sample was taken for the analysis of fresh beans. Samples for fresh analysis were divided further by removing the seed from one-half of the sub-sample. Then each lot was cut in ¼ in. lengths, weighed in duplicate into 2 oz paper cups, frozen, and freeze-dried for 36 hr at a pressure of 5μ. The dry samples were weighed to obtain total solids before grinding in a Wiley mill to a powder. Dry samples were sealed in plastic vials and stored at 0°F until analyses were made.

The snap beans for canning were snipped by hand and blanched at

Table 1. The effect of size and variety on carbohydrates in canned snap beans (dry basis).

	% Total sugars		% Starch		% Water-sol. Pectin	
Varieties	Pods	Seed	Pods	Seed	Pods	Seed
Gallatin 50	25.15	14.16	12.30	9.35	4.041	0.592
Tenderette	23.98	14.14	7.88	12.30	5.105	2.403
Trugreen	24.25	12.17	6.71	21.86	3.608	1.188
XP-274	24.40	14.28	5.99	13.46	3.897	0.623
Ky Wonder	22.57	12.65	1.50	10.51	4.568	1.812
OSU-949	17.45	7.55	5.12	16.25	4.938	2.169
OSU-8224	21.41	12.46	6.25	11.25	4.239	0.755
OSU-8353	19.07	10.49	4.52	11.93	4.601	2.122
OSU-9155M	18.81	7.96	6.46	11.32	4.582	1.907
OSU-9827	20.25	10.26	5.02	15.60	3.768	1.238
F value	5.094**	4.321**	4.273**	9.030*	5.545**	41.663**
LSD .05	3.51	3.45	3.86	3.50	.620	.308
Sieve Size						
3	23.24	15.15	2.69	7.62	4.251	1.698
4	23.23	13.35	5.24	11.33	4.427	1.555
5	21.17	9.94	7.56	16.19	4.323	1.405
6	19.29	8.00	9.21	18.80	4.339	1.265
F value	6.142**	18.500**	11.39**	42.71**	.285	7.751**
LSD .05	2.22	2.18	2.44	2.22	NS	.195

* 5% level. ** 1% level of significance.

175°F for 2 min. After cooling in tap water the whole beans were packed in "303 × 411" cans to a fill of 9 oz. Boiling water and a 75 g salt tablet were added to complete the fill. Then the cans were sealed and processed for 20 min at 240°F.

After 3 months storage the canned beans were separated into pods and seed and analyzed by the procedures previously described (Sistrunk, 1965a).

Analyses of freeze-dried samples were made on 0.2 g of dry material by the same procedure except each sample was taken up in 10 ml of boiling water and boiled 10 min to gelatinize the starch prior to digestion with Taka-diastase.

Standard statistical methods were followed in analyzing the data. Only a portion of the data was chosen to discuss the differences obtained.

Table 2. Interaction of size and variety on constituents of canned beans.[1]

a. % total sugars in pods and seed.

	Sieve Sizes					
	Pods			Seed		
Variety	3	4	5	3	4	5
Gallatin 50	30.2	26.4	25.0	21.3	19.2	8.9
Trugreen	29.7	26.9	20.6	16.0	15.1	9.6
XP-274	26.4	24.8	23.7	20.0	17.1	11.4
Ky Wonder	22.2	23.3	23.1	13.3	13.1	12.7
OSU-949	18.1	18.2	17.9	9.8	8.8	5.6
OSU-9827	21.4	20.1	20.7	11.6	11.5	9.8

b. % starch in pods and seed.

	Sieve Sizes					
	Pods			Seed		
Variety	3	4	5	3	4	5
Gallatin 50	1.6	12.9	17.6	3.5	6.4	11.3
Trugreen	4.2	6.5	8.6	12.3	18.2	26.8
XP-274	2.5	5.4	8.0	4.0	11.4	16.9
Ky Wonder	0.2	0.6	1.8	6.2	8.4	11.9
OSU-949	3.3	4.7	6.5	13.6	15.8	16.9
OSU-9827	1.2	5.8	5.6	6.5	10.3	14.0

c. % water-soluble pectin in pods and seed.

	Sieve Sizes					
	Pods			Seed		
Variety	3	4	5	3	4	5
Gallatin 50	4.16	4.28	3.88	.64	.59	.51
Trugreen	4.28	3.63	3.33	1.36	1.39	1.04
XP-274	3.82	3.80	4.04	.51	.59	.73
Ky Wonder	3.92	4.47	4.79	1.84	1.97	1.83
OSU-949	4.76	5.27	4.53	2.58	2.44	1.76
OSU-9827	4.16	4.55	4.76	2.39	2.08	2.12

[1] Interactions were not significant.

Table 3. The effect of size and variety on carbohydrates in canned snap beans (dry basis).

	% Cal-sol Pectin		% Hemicellulose		% Cellulose	
Varieties	Pods	Seed	Pods	Seed	Pods	Seed
Gallatin 50	1.966	1.167	2.919	6.738	11.129	19.704
Tenderette	2.116	1.322	2.638	1.847	10.539	10.277
Trugreen	4.028	1.173	2.673	3.340	12.599	10.843
XP-274	2.682	1.121	1.961	3.440	10.031	13.845
Ky Wonder	2.647	2.149	2.066	2.385	12.820	14.245
OSU-949	2.412	1.404	2.132	6.468	12.351	12.705
OSU-8224	2.167	1.729	3.072	6.377	11.432	25.311
OSU-8353	2.799	1.639	2.159	3.880	11.296	12.222
OSU-9155M	3.037	1.714	2.663	12.906	10.116	12.906
OSU-9827	2.679	1.744	2.635	2.950	12.310	16.559
F value	6.654**	38.749**	2.338*	6.457**	0.931	18.225**
LSD .05	.663	.155	.963	2.747	NS	3.121
Sieve Size						
3	2.366	1.697	2.042	3.245	11.029	14.532
4	2.754	1.618	2.355	4.002	11.423	13.889
5	2.456	1.487	2.607	4.811	11.347	15.260
6	3.037	1.262	2.964	8.094	11.979	15.765
F value	4.470*	31.683**	3.460*	6.840*	0.355	1.464
LSD .05	.418	.098	.609	2.368	NS	NS

* 5% level. ** 1% level of significance.

RESULTS AND DISCUSSION

For the purpose of making comparisons, Gallatin 50 and Trugreen were designated as regular bush types. The selection XP-274 fitted into this type in most of the chemical constituents. The OSU selections 949 and 9827 have been backcrossed at least three times to Blue Lake pole beans so it was assumed that these selections have more characteristics of Blue Lake pole beans than the regular bush type. Kentucky Wonder was closely related to the Blue Lake types in carbohydrates and subsequent changes with maturation. The remainder of the selections and Tenderette followed different patterns, depending on maturity and the particular chemical or physical test.

The differences that occurred between the regular bush type beans and the Blue Lake type were evident in both canned and fresh beans, although the magnitude of the differences varied greatly with maturity. Total sugars and starch content were higher in the regular bush type when comparing the main effects of variety and sieve size (Table 1). The magnitude of the differences can be better demonstrated by the interaction of variety and size (Table 2). Although this interaction in canned beans was not significant in most chemical and physical determinations, brief tables that do not include all the varieties and sizes are shown to clarify discussion of the major differences between the types of beans. The relative significance of the data in the brief tables may be obtained from the tables of main effects.

The decrease in sugar content with an increase in sieve size of pods was more pronounced in the regular type as compared to Blue Lake type and Kentucky Wonder (Table 2a). Changes in the seed were even more rapid in the regular bush type, whereas Kentucky Wonder and the OSU selections 949 and 9827 changed comparatively little in either sugar or starch during maturation (Tables 2a and 2b). The rate of change from sugar to starch in the pods and seeds appeared to be one of the distinguishing characteristics between the two types. For example, there was an accumulation of 17.6% starch in pods of 6 sieve beans of Gallatin 50 and 30.2% in seed of 6 sieve beans of Trugreen.

The water-soluble pectin in pods of regular types decreased with maturation while there was a general increase in most of the Blue Lake types and Kentucky Wonder (Table 2c). Water-soluble pectin was also higher in the seed of Blue Lake types regardless of

sieve size. The variety Tenderette was highest in water-soluble pectin in the pods and Trugreen the lowest (Table 1).

Differences between the two types were not always apparent when comparing Calgon-soluble pectin, hemicellulose and cellulose of canned beans (Table 3). However, the Calgon-soluble pectin and cellulose increased markedly in pods of fresh beans of Gallatin 50 and Trugreen, but the increase was less pronounced in the OSU selections and Kentucky Wonder (Table 4a). The variety Trugreen was highest in Calgon-soluble pectin in the pods of canned beans, yet the OSU selections and Kentucky Wonder contained large quantities in the seed (Tables 3 and 5). The variety Gallatin 50 and OSU selections 949, 9155M and 8224 accumulated large amounts of hemicellulose in the seed. In addition, Gallatin 50 and OSU 8224 contained large amounts of cellulose in the seed. These were the selections that developed larger seed in the 5 and 6 sieve pods. The differences in hemicellulose and cellulose in pods of canned beans between varieties was negligible. There was apparently a change in solubility of cellulose during processing since there were larger differences between varieties in the fresh than in canned beans (Tables 3 and 4a).

Protopectin increased in the pods with an increase in sieve size (Table 4b). Higher percentages of protopectin were exhibited in OSU selections 949 and 9827 in 5 sieve beans. It has been demonstrated in other studies that practically all the protopectin was converted to water- and Calgon-soluble pectin during canning (Sistrunk, 1960). Also, fresh snap beans contain only a negligible amount of water-soluble pectin. Furthermore, it was shown that there was an increase in sloughing with an increase in sieve size in Blue Lake pole beans. In Trugreen, Gallatin 50 and XP-274, there was a decrease in sloughing with an increase in sieve size (Table 5), which probably was directly related to the increase in Calgon-soluble pectin of fresh beans with sieve size in these varieties (Table 4a).

The fiber content did not exceed the FDA tolerance of 0.15% in any of the canned beans except the 6 sieve pods of Trugreen and OSU-9155M. This was also indicated by the greater resistance to shear (Table 6). A number of varieties and selections increased markedly in fiber, seed and resistance to shear between the 5 and 6 sieve beans as shown by the significant differences between the means for sizes. The different types of beans did not exhibit the same chemical and physical changes either during maturation or during processing. Significant interactions between variety and sieve size occurred only in total sugars, starch and water-soluble pectin in fresh beans and sloughing of canned beans. These interactions nullified sta-

Table 4. Interaction of size and variety on carbohydrates in fresh bean pods.[1]

a. % Calgon-soluble pectin and cellulose

Variety	% Cal-sol pectin (Sieve Sizes) 3	4	5	% Cellulose (Sieve Sizes) 3	4	5
Gallatin 50	1.86	2.18	3.85	7.13	10.25	17.50
Trugreen	2.13	2.69	3.65	12.38	15.25	17.00
XP-274	2.15	2.74	3.27	11.50	14.50	17.25
Ky Wonder	2.03	2.25	2.50	10.75	7.25	15.25
OSU-949	3.12	3.48	3.27	9.25	7.38	12.13
OSU-9827	2.42	2.47	2.89	6.85	10.75	11.25

b. % Hemicellulose and protopectin

Variety	% Hemicellulose (Sieve Sizes) 3	4	5	% Protopectin (Sieve Sizes) 3	4	5
Gallatin 50	.90	.98	2.57	2.89	2.36	3.55
Trugreen	1.19	1.20	1.55	2.96	3.75	3.85
XP-274	1.07	1.08	1.58	2.46	3.22	3.56
Ky Wonder	1.42	1.20	1.24	3.65	3.55	3.27
OSU-949	1.15	1.08	1.22	2.92	3.60	4.35
OSU-9827	.89	.83	1.30	2.85	3.17	4.15

[1] Interactions not significant.

Table 5. The interaction of size and variety on percent Calgon-soluble pectin in seed and sloughing in pods of canned beans.[1]

Variety	(seed) % Calgon-soluble pectin (Sieve sizes) 3	4	5	ml/100 g sloughing (pods) (Sieve sizes) 3	4	5
Gallatin 50	1.29	1.23	1.02	6	7	5
Trugreen	1.38	1.39	.88	4	3	2
XP-274	1.26	1.15	.97	4	3	3
Ky Wonder	2.28	2.36	1.85	5	4	5
OSU-949	1.59	1.58	1.18	8	6	11
OSU-9827	2.01	1.91	1.39	5	6	8

[1] Interactions were not significant except in sloughing of pods.

Table 6. The effect of size and variety on quality factors of canned snap beans.

Varieties	% Dry Matter Pods	% Dry Matter Seed	Sloughing ml/100 g	Shearpress (lbs)	% Seed	% Fiber
Gallatin 50	8.21	15.36	6.25	55.5	5.35	.020
Tenderette	7.87	10.49	8.00	37.3	4.25	.018
Trugreen	8.36	14.84	3.50	94.3	8.48	.071
XP-274	7.62	13.31	3.25	54.8	4.45	.008
Ky Wonder	8.28	13.06	5.25	73.0	6.00	.040
OSU-949	7.97	15.31	8.50	82.3	9.45	.040
OSU-8224	8.25	13.91	8.25	74.3	8.10	.041
OSU-8353	8.00	12.80	6.75	106.0	5.80	.047
OSU-9155M	7.36	14.86	7.25	113.3	6.33	.063
OSU-9827	8.28	14.50	5.75	87.8	7.70	.063
F value	1.712	4.148**	5.777**	2.332*	3.964**	2.001
LSD .05	NS	2.13	2.25	45.5	2.57	NS
Sieve Size						
3	7.93	11.26	6.20	62.0	3.60	.014
4	7.83	12.84	5.90	64.7	4.89	.023
5	8.01	14.77	6.50	69.4	7.21	.035
6	8.32	16.52	6.50	115.2	10.66	.093
F value	1.795	24.244**	0.344	6.427**	30.689**	14.010**
LSD .05	NS	1.35	NS	28.7	1.62	.044

* 5% level. ** 1% level of significance.

tistical differences when comparing the means for sieve sizes, especially in sloughing of canned beans. Many of the most important differences were exemplified only by comparing the changes that took place during maturation.

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Aroma Concentration for Dehydrated Foods

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SUMMARY

A process for making aroma concentrates suitable for addition to dehydrated foods was developed. The process consists of vacuum stripping with a noncondensable gas and collecting the aroma in refrigerated traps at atmospheric pressure. Aroma concentrates of 1000-fold or more were possible without redistillation or extraction. Aroma was stripped and concentrated from orange, apple and tomato juices.

Material balances of the aroma compounds in Delicious apple juice were made using both gas liquid chromatograph and odor threshold analyses. These showed that most of the aroma in the feed appeared in the aroma concentrates and only small amounts of material were lost in the other streams leaving the process.

When orange aroma was condensed on orange powder, a substantial amount of fresh orange aroma was added without a large increase in moisture.

INTRODUCTION

Most foods when dehydrated lose many of the volatile compounds which characterize their flavor. There have been studies to determine conditions under which volatiles are retained during drying (Menting *et al.,* 1967; Saravacos *et al.,* 1968); however, the more widely used approach is that of adding back the lost volatiles to the final product. Encapsulation of the aroma compounds in amorphous sugar is an established technique for adding aroma back to dehydrated citrus products, in which the peel oil provides a concentrated, non-aqueous source of aroma (Schultz *et al.,* 1956). Whenever the aroma compounds desired are in a dilute aqueous solution, such as apple or grape juice, the compounds are concentrated by distillation to a 100-fold aqueous solution, and then redistilled to a higher concentration or extracted with a suitable solvent which is subsequently distilled off (Dimick *et al.,* 1957, Turkot *et al.,* 1956). The resulting aroma concentrate can be either added directly to the dehydrated product or encapsulated in amorphous sugar (Dimick *et al.,* 1957, Turkot *et al.,* 1956).

Extraction or redistillation processes have inherent losses of aroma associated with them, and they both require starting with a partially concentrated aroma solution. This work describes a process which uses a single strength juice as feed and concentrates the aroma compounds in one operation sufficiently for addition to dehydrated foods. This process provides a high recovery of aroma compounds and is simpler than either extraction or redistillation techniques.

PROCESS AND APPARATUS

In 1966 the WURVAC process for making aroma solutions suitable for adding to food concentrates was described (Bomben *et al.,* 1966, 1967). This WURVAC process can be modified to make aroma concentrates which are suitable for dehydrated food products. Fig. 1 is a schematic drawing of this new process, and Table 1 describes

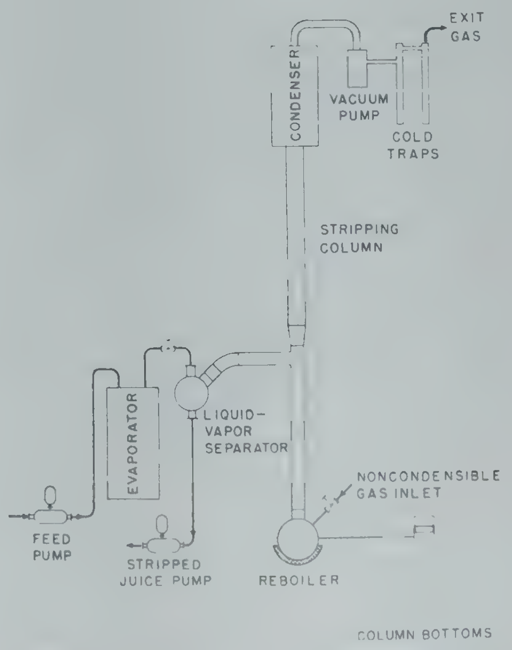

Fig. 1. Schematic diagram of aroma concentration process.

Table 1. Description of pilot plant apparatus for aroma concentrate process.

Feed pump	Sigmamotor, Model T-8
Evaporator	10 ft long × ¼ in. I.D. coil of stainless steel tubing in a 3½-in. O.D. × 8 in. long cylindrical jacket.
Liquid—vapor separator	500 ml round bottom flask with 24/40 ₮ fittings for feed, 28/15 mm ball joint for stripped juice and a 50/30 mm ball joint for vapor.
Stripped juice pump	Monostat Corp. Varistatic Pump, Cat. No. 72-590 60.
Stripping column	46 cm long × 35 mm I.D. above feed, 46 cm long × 27 mm I.D. below feed, 29/42 ₮ joints, and packed with 3⁄16 in. glass helices.
Reboiler	500 ml round bottom flask in a 250 watt electrical heating mantle with a 29/42 ₮ joint at top, a 12/3 mm ball joint for gas inlet, and 35/25 mm ball joint for column bottoms outlet.
Condenser	Allihn type, 40 mm smallest I.D. and 50 mm largest I.D. and 65 cm long.
Vacuum pump	Decora Mfg. Co., Model 2 DV. Inside of the pump was coated with a chemically deposited nickel alloy and a thin Teflon cover was installed over the neoprene diaphragm.
Cold traps	Standard vacuum cold trap fitted with a graduated centrifuge tube at the bottom.

Table 2. Typical operating conditions.

Feed material	Orange juice, tomato juice, apple juice, "synthetic solutions"
Feed-rate	1000 ml/hr
Evaporation rate	250–300 ml/hr
Reboil rate	280 ml/hr
Evaporator temperature	135°F (25 in Hg vacuum)
Condenser temperature	40°F
Nitrogen flow rate	100–200 cc/min @ atmospheric conditions
Aroma concentration olumetric ratio	1000–2500

the pilot plant apparatus.

A portion of the feed was vaporized in the evaporator, and at the liquid-vapor separator the unvaporized juice (stripped juice) was drawn off for further processing. The vapor leaving the liquid-vapor separator entered the stripping column where it was refluxed. The condensate (column bottoms) was withdrawn from the reboiler to a vacuum receiver. The aroma concentrate was obtained by introducing a stream of noncondensable gas at the reboiler and passing it through the column to the diaphragm vacuum pump which compressed and fed it to the cold traps where the volatiles were condensed.

Table 2 shows the operating conditions used in most of the experiments. Orange, apple and tomato juices, as well as solutions of esters, alcohols and aldehydes were all used as feed materials. In the evaporator the feed was heated rapidly to 175°F and after passing through a throttling valve, 25 to 30% of it was flash evaporated. The reboil rate (calculated assuming 75% efficiency in the 250 watt electrical heating mantle) was kept at 280 ml/hr. With a nitrogen flow rate of 200 cc/min the maximum vacuum attainable at the reboiler was 25 in. of Hg. This gave a boiling temperature of approximately 135°F at the exit of the evaporator. Twenty-eight inches of Hg vacuum was possible if two of these pumps were connected in series. The vacuum pump had to be maintained at 120°F with electrical heating tape to prevent condensation in the compression chamber and insure complete transferal of aroma to the dry ice traps.

With pure water in the condenser, a nitrogen flow rate of 200 cc/min (25°C, 1 atm), a condenser temperature of 40°F and a vacuum of 25 in. of Hg the ratio of volume of feed to volume of aroma concentrate was calculated to be 2100. In the experiments this ratio varied from 1000 to 2500 depending on the nitrogen flow rate chosen for a particular feed material.

In an attempt to achieve steady-state operation the apparatus was always run under the chosen conditions for approximately 4 hr before aroma was collected. After this time the cold traps were put into the dry-ice, acetone bath and aroma was collected for 1½ hr. The cold traps were then disconnected from the pump, sealed and allowed to thaw, and the amount of liquid was read from the graduated cylinder at the base of the cold traps. Composite samples of the feed, stripped juice, and column bottoms were taken for gas-liquid chromatography and odor threshold analyses. In those experiments where mass balances of the aroma compounds were being made, the traps were washed down with 10 ml of water after thawing and draining. Also a 500 ml water scrubber in an ice bath connected to the exit of the cold traps was used to measure any loss with the nitrogen discharged to the atmosphere.

MATERIAL BALANCE STUDIES

Methods. Although it was known that this process could produce a strong aroma concentrate characteristic of the feed, a quantitative measure of the recovery attainable was desirable. Gas-liquid chromatographic (GLC) techniques are quantitative and give results which can be used to examine the behavior of different kinds of compounds in the aroma recovery process. The direct vapor headspace analysis with a dual hydrogen flame detector, as described by Teranishi *et al.* (1962), is a simple technique for measuring volatile compounds at very low concentrations.

The following procedure was used in the GLC analyses for these experiments. A 50 ml sample was put in a 250 ml Erlenmeyer flask, tightly covered with aluminum foil and equilibrated in a 25°C constant temperature bath for 1 hr. A 5 ml sample of the headspace was injected into a ¼ in. × 20 ft column packed with Chromosorb G and coated with 4% by weight of SF96-50. Column temperature was 100°C with a carrier gas (nitrogen) flow rate of 4.7 cm/sec at atmospheric conditions. All samples for analysis were diluted to approximately the same concentration as the feed. The amount of volatile compounds in the three streams leaving the process was determined by measuring the peak heights in the chromatograms and comparing them to their heights in the feed solution. Hence a material balance was made on each of the peaks in the chromatogram.

The volatile compounds measured with the GLC do not all contribute equally, or in proportion to their concentration, to the aroma of a food. The odor threshold of a solution can be used as a measure of the concentration of compounds actually contributing to the aroma. Again, if the feed is used as a standard, the odor threshold of the streams leaving the process will measure the concentration of aroma in them and provide a means for making a material balance on the overall aroma. The method used for measuring odor threshold is described by Guadagni *et al.* (1963).

By using commercial essence diluted to single strength, rather than the ac-

Table 3. Material balances by GLC and odor threshold as percent of material in feed (diluted red Delicious apple essence).

GLC peak number [1]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Odor threshold
Strip. juice	13	24	12	10	14	9	11	8	8	8	8	8	7	6	nil	17
Aroma concentrate	7	85	39	44	94	73	98	65	77	73	53	95	63	63	41	48
Scrubber	70	3	36	19	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	1
Total [2]	90	112	87	73	108	82	109	73	85	81	61	103	70	69	41	66

[1] Peak No. 1—acetaldehyde
Peak No. 9—hexanal
Peak No. 11—ethyl 2-methyl butyrate
Peak No. 13—2-hexenal
Peak No. 15—hexyl acetate
[2] The column bottoms showed no appreciable amount of material in the GLC or odor threshold analyses.

tual fruit juice, as feed in the material balance experiments, errors in the results which could arise due to the presence of solids in the feed or changes in its aroma with time were avoided. Our laboratory has had an extensive research program on the identification of the compounds contributing to the aroma of Delicious type apple juice; consequently we chose to work with this essence using these prior results to help in the analysis of the data.

Results. The chromatograms in Fig. 2 are of a commercial apple essence (Tree Top, Inc.) diluted to single strength and the aroma concentrate produced from this solution. The aroma concentrate was diluted 1400 to 1 making the peak heights in the two chromatograms of comparable magnitude.

In Table 3 the results of a material balance made by measuring heights of the 15 peaks shown in Fig. 2 are given as well as the material balance made by odor threshold analysis. The feed represents 100% in each of these compounds and the stripped juice, column bottoms and aroma concentrate are the three streams leaving the aroma recovery process. The scrubber is an additional sample collected to measure any loss from the dry-ice traps.

It is evident that most of the apple aroma is removed from the feed and practically none is lost in the column bottoms. This has been generally true in all of our experiments except for those using unheated tomato juice in which there was a detectable aroma in the column bottoms and a substantial aroma in the stripped juice.

Most of the acetaldehyde does not condense in the cold traps and is lost to the scrubber. This is characteristic of the highly volatile compounds found at the front of the chromatogram. In apple these types of compounds are not major contributors to the aroma, but this is not true for all foods.

The identification work done at this laboratory has established that hexanal, 2-hexenal and ethyl 2-methyl butyrate are the major contributors to Delicious apple aroma (Flath *et al.*, 1967). These all show a recovery in the aroma concentrate which is comparable to that obtained by odor threshold analyses, thus showing that this process recovers the essential compounds in Delicious apple aroma.

A substantial amount of aroma is unaccounted for in these material balances. In an attempt to determine the reasons for the disappearance of these aroma compounds, a model solution was made using compounds known to be in apple essence but at 10 to 100 times the concentration. Three of these compounds—hexanal, ethyl 2-methyl butyrate, and 2-hexenal—are the ones known to be important in apple aroma, and the fourth, hexyl actetate, consistently showed the largest unexplained loss in our experiments. Table 4 shows the material balances resulting in an experiment run under the same conditions for the material balances shown in Table 3 but using a feed solution made up of 12.5 ppm of each of the above compounds.

Although the material balances in Table 4 do not account for all of the compounds in the feed, in general the unaccounted for material is less than when diluted apple essence was used. The disappearance of aroma could be due to adsorption on the surfaces of the vacuum pump and condenser. The

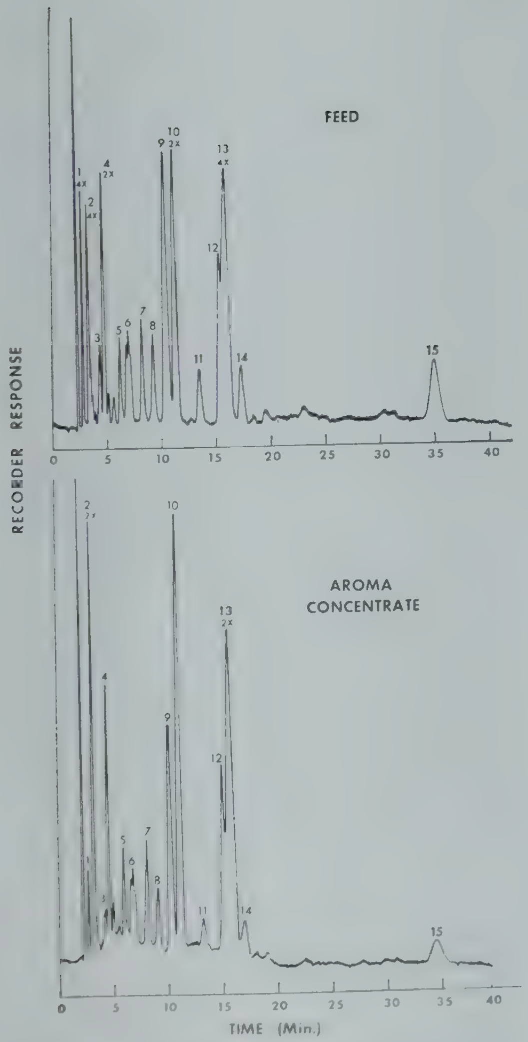

Fig. 2. Chromatograms of red Delicious apple essence feed (diluted to single strength) and aroma concentrate (diluted 1400:1) made in material balance experiments.

Table 4. Material balances by GLC and odor threshold as percent of material in feed (12.5 ppm each of hexanal, ethyl 2-methyl butyrate, 2-hexenal and hexyl acetate).

GLC peak number	9	11	13	15	Odor threshold
	(hexanal)	(ethyl 2-methyl butyrate)	(2-hexenal)	(hexyl acetate)	
Stripped juice	13	10	10	4	35
Aroma concentrate	76	66	93	56	81
Scrubber	nil	nil	nil	nil	1
Total [1]	89	76	103	60	117

[1] The column bottoms showed no appreciable amount of material in the GLC or odor threshold analyses.

low concentration of some of these aroma compounds in the diluted apple essence may not provide enough material to saturate these surfaces in the 4 hr the apparatus was run before collecting the aroma concentrate.

Chemical breakdown of aroma compounds cannot explain their disappearance. It was found that heating the 100-fold apple essence used in the feed for 2 hr at 120°F did not alter the chromatogram at all.

CONDENSATION OF AROMA ON ORANGE POWDER

The manner in which the aroma can be added back to a dehydrated product has not been thoroughly investigated in this work, since to a large extent the technique used will depend on the product and its use. With the process described in this paper a rather simple technique for directly adding aroma to a dehydrated product is possible. If the product remains free flowing at low temperatures, the gas leaving the vacuum pump can be passed through the dehydrated product condensing the aroma directly on it.

At 1000-fold the aroma concentrate would add 1% to the moisture content of a dehydrated food that was originally 10% solids. In the pilot plant unit described in this paper with an orange juice feed rate of 1 L/hr and a nitrogen flow rate of 200 cc/min, the amount of aroma concentrate collected is 0.9 ml/hr. When a foam-mat orange powder (Graham *et al.,* 1965) was contacted with orange aroma in a cold trap as shown in Fig. 3, the moisture content of the powder went from 2.6 to 3.0%, but it remained free flowing and did not show any noticeable change in physical properties.

Fig. 4 shows chromatograms of this orange powder before and after aroma addition. There is a large increase in the size of peaks in the chromatogram after aroma addition, especially in the water soluble peaks shown within the first 20 min of the chromatogram. These peaks are not available in orange peel oil, and the compounds in this group are believed to account for a substantial part of fresh orange aroma.

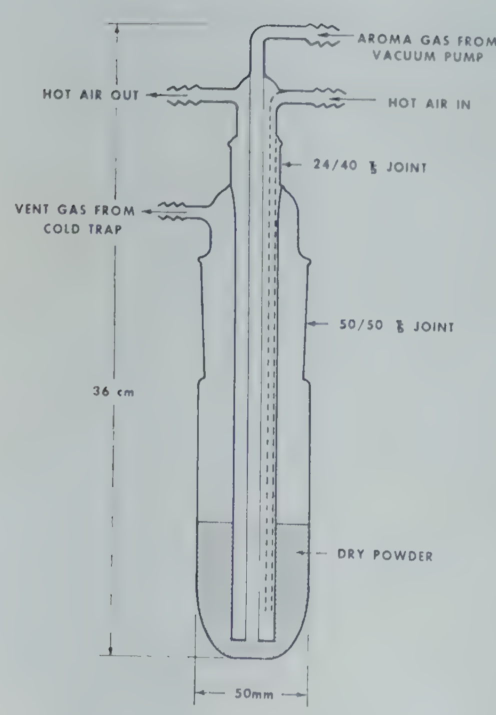

Fig. 3. Cold trap used for absorbing aroma on dehydrated foods.

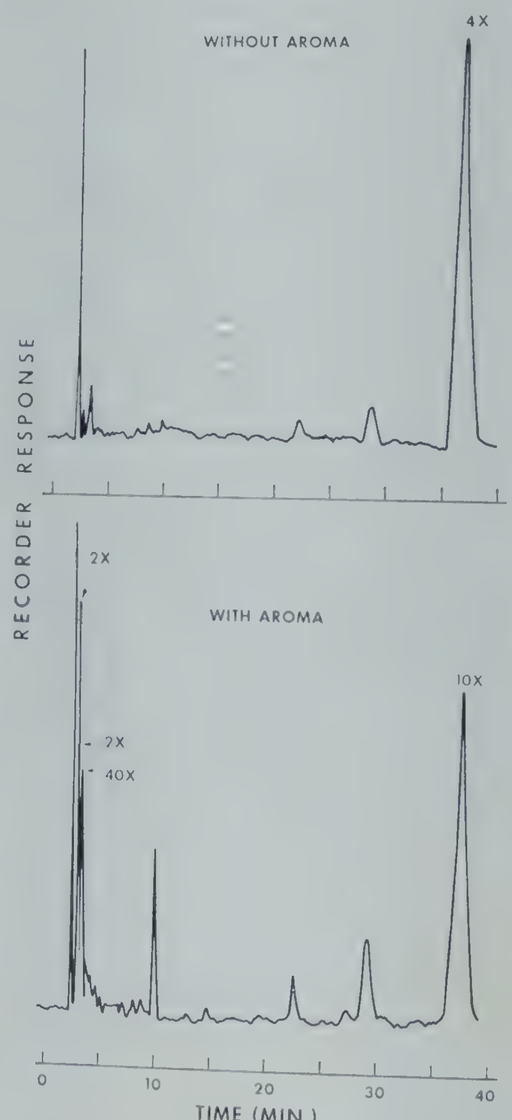

Fig. 4. Chromatograms showing the effects of aroma absorption on a foam-mat dried orange powder. Twenty-five g of the powder were mixed with the aroma of 300 ml of fresh orange juice by means of the cold trap shown in Fig. 3.

CONCLUSION

Material balances done with GLC and odor threshold analyses showed that this aroma recovery process could remove and concentrate to 1000-fold or more the volatile flavor of apple and orange juices. The process operated under conditions which did not harm the feed juice and did not require any solvent extraction.

Many dehydrated products, such as orange powder, lack much of the flavor which is characteristic of the original material. A 1000-fold aroma concentrate is a starting point for adding natural volatile flavor to dehydrated foods. Direct condensation of 1000-fold orange aroma on dehydrated orange powder was a technique of aroma addition demonstrated in this work.

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Reference to a company name does not imply approval or recommendation of the product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

Processing and Preservation of Ginger by Syruping under Atmospheric Conditions

1. Preliminary Investigations of Vat Systems

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SUMMARY

Two vat systems for processing ginger are outlined, one containing three vats in series, the other six vats in series. Characteristics of each processing system are discussed, with respect to color of the processed product, syrup pH and flowrate, percent weight increase, and sucrose:reducing sugar ratios of syrup during processing. The ginger was processed during a four-day period, and allowed to reach equilibrium in the final syrup over a further two days. .

For satisfactory sugar absorption, weight gain, and desirable color and texture, the results indicated that optimum conditions for processing ginger under atmospheric conditions would require a three-vat system and a constant vat temperature of 125°F to 135°F, provided syrup flow rate through the vat system was maintained. It was found that processing of ginger had to be carried out at a syrup temperature not exceeding 140°F in order to minimize inversion of sucrose.

INTRODUCTION

Traditional methods of preserving ginger by immersion in syrups consisting of a mixture of dissolved sugars have been practiced in China and India for centuries. The art of processing these products for confectionery remained basically unchanged, and very little was published about either the cultivation of ginger or its commercial production until the early 1900's.

A general article on ginger cultivation and production appeared in the Bulletin of the Imperial Institute (Anon., 1926) and since then further information has become available on the production of preserved ginger (Brown, 1955). Certain improvements in the actual operation of syrup concentration were made by Pentzer *et al.* (1942), and Atkinson *et al.* (1952) and experiments were carried out by Leverington (1961) into methods for more efficient diffusion of syrup into ginger during the syruping process.

A considerable amount of investigational work carried out in the U.S.A. on fruit candies (Cruess, 1946) and fruit products (Cruess *et al.*, 1949) indicated the inherent versatility and adaptability of the syruping process as applied to fruit products generally. Ingleton (1964) presented further information on the manufacture of candied fruit, and the preservation and crystallization of ginger in particular has been discussed (Ingleton, 1966).

In commercial processing, ginger is subjected to an initial prolonged boiling treatment prior to syruping to soften it, remove sulphur dioxide and some of the hot flavor. It is then placed in syrup of approximately 20% T.S.S. and 7.0% reducing sugars, and thereafter for some 12 to 14 days the syrup is concentrated to approximately 72 to 75% T.S.S. by vacuum concentration or by the addition of sucrose. In commercial practice, it is necessary to obtain maximum absorption of sugars by the ginger in the shortest possible time, and a maximum drained weight at equilibrium in high-T.S.S. syrup.

The initial experiments described below were designated to investigate basic syruping methods.

MATERIALS AND METHODS

Preparation of invert sugar and sugar syrup. A quantity of 100% invert syrup was prepared by the method of Campbell (1937) using tartaric acid for inversion. Conditions for the formulation and storage of sucrose/invert syrup, as recommended by James (1955), Backes *et al.* (1957), and Adcock, were used in which syrup containing sucrose:invert in the ratio 2:1 was concentrated to at least 65 T.S.S., acidulated to pH 4.00, and preserved in the case of prolonged storage by the addition of potassium metabisulphite. To prevent the growth of microorganisms, especially in low T.S.S. syrups, pasteurization was carried out at 180°F for several minutes, and the syrup cooled quickly to avoid excessive inversion of sucrose.

Analytical Methods. *Total Soluble Solids (T.S.S.).* Percent T.S.S. of the syrup was determined by refractometer, and the actual reading corrected for temperature and percent reducing sugars present in the syrup—de Whalley factor (Davis *et al.*, 1955).

pH. pH was determined using the conventional glass electrode/calomel electrode system.

Chemical analyses for sugars. Percent reducing sugars was determined by the method of Lane and Eynon (Horwitz, 1960). Preparation of samples was carried out by a method similar to that used for jams (Københavns Pektinfabrik, 1952). Percent sucrose in the syrup was calculated from percent T.S.S. by difference.

Sucrose/reducing sugar ratio was calculated from results of chemical analyses.

EXPERIMENTAL

In commercial practice, vats connected in series are used. In this series of experiments two systems were investigated, namely three vats and six vats in series, each vat having a capacity of 3 L.

Three-vat system. Fig. 1 indicates schematically the arrangement of the vat system employed. Syrup from the evaporator entered Vat 1 at approxi-

mately 140°F and pH 4.0, and was forced through each vat system at a regulated flow rate, to be exhausted finally from Vat 3 into a bulk tank where it was pumped through the evaporator for concentration. No heat insulation or control system was used on the vats and the temperature of the syrup thus fell to 117°F as the syrup progressed from Vat 1 to Vat 3.

Screens were used to submerge the entire charges of ginger in the vat syrup throughout the syruping process. Syrup was thus forced to flow from the base of each vat up through the ginger and out through an overflow at the top. The T.S.S. rise during the 4-day processing was controlled by concentrating the syrup in the evaporator each day as follows:—

1st day—30 to 35 TSS; 2nd day—35 to 47 TSS; 3rd day—47 to 65 TSS; 4th day—65 to 75 TSS.

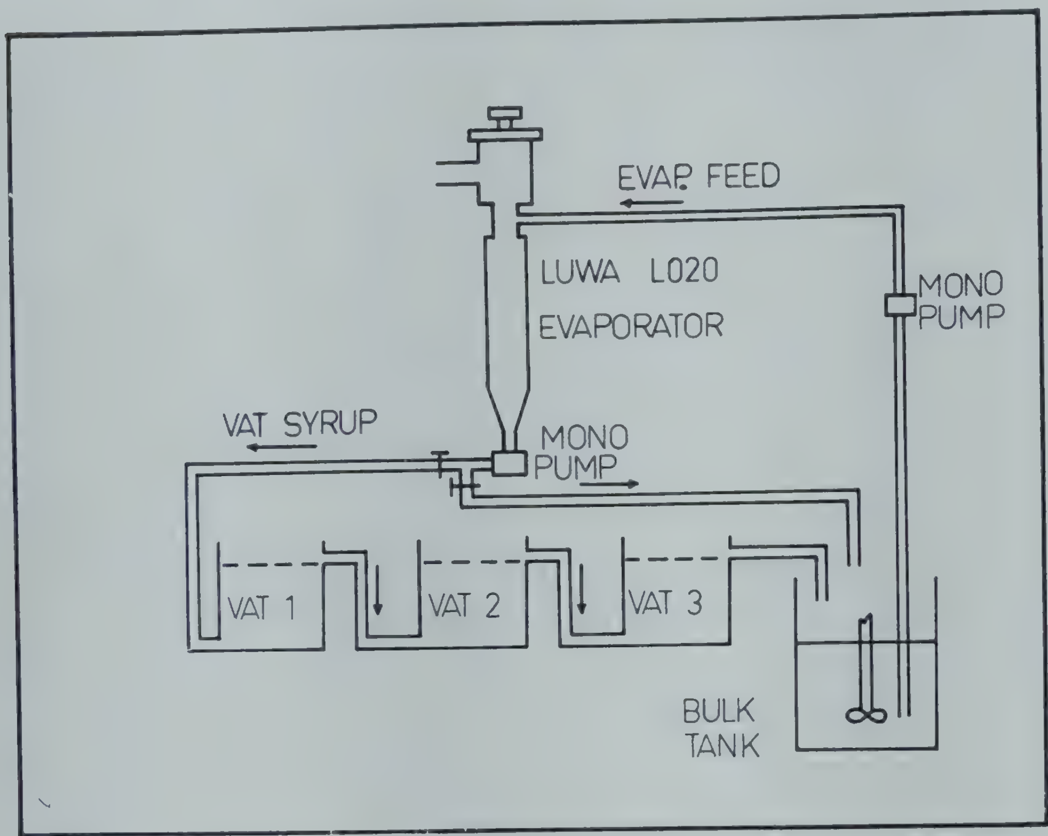

Fig. 1. Three-vat system.

RESULTS AND DISCUSSION

Results of analyses on syrup and ginger are presented in Tables 1 and 2.

There was a continual drop in T.S.S. from Vat 1 to Vat 3, probably due to the drop in temperature which may have affected the syrup absorption of the ginger pieces. This was reflected in the percent reducing sugar (R.S.) value of the final evaporated syrup compared with the value in each vat at equilibrium (Table 1c), although the ginger in each vat showed good syrup penetration throughout the pieces as indicated by the reducing sugar values of inner and outer portions.

Unsaturation of the ginger in Vats 2 and 3 immediately after processing was reflected in the comparatively large syrup T.S.S. drop in Vats 2 and 3 at equilibrium (Tables 1b, 1c). This again indicated an effect of temperature during the syruping operation.

Temperature. The syrup was heated during evaporation under vacuum from 104°F to 137°F in the evaporator in order to achieve an average temperature of 136°F for syrup in Vat 1. Sucrose inversion was not expected to be excessive, as the rather high evaporator temperatures were maintained for 1 min only during each pass.

Syrup temperature decreased through

Table 1. Three-vat system—summary of average values.

(a) *Control features*

* Syrup evaporation					Vat syrups 1		Vat syrups 2		Vat syrups 3		Exhausted syrup		Flow rate ml/min.			
PFT	PVT	PVP	T	pH	T	pH	T	pH	T	pH	T	pH	Day 1	Day 2	Day 3	Day 4
104	167	350	137	3.92	136	3.91	126	3.91	117	3.91	106	3.92	215	180	170	170

* PFT: Product feed temperature (°F) (to evaporator)
PVT: Product vapor temperature (°F)
PVP: Product vapor pressure (mms Hg)
T: Temperature (°F) ex Evaporator).

(b) *Analyses on syrups immediately after processing*

Evaporated syrup				Vat syrups 1			Vat syrups 2			Vat syrups 3		
TSS	pH	T	R.S.	TSS	pH	T	TSS	pH	T	TSS	pH	T
75.0	3.90	137	25.7	75.1	3.98	136	74.9	3.95	126	74.7	4.00	117

TSS = Corrected TSS reading by refractometer.

(c) *Analyses (after 2 days) at equilibrium*

Vat syrups 1		Vat syrups 2		Vat syrups 3		Drained ginger from vats 1 Red. sugars		Drained ginger from vats 2 Red. sugars		Drained ginger from vats 3 Red. sugars	
TSS	pH	TSS	pH	TSS	pH	Inner	Outer	Inner	Outer	Inner	Outer
74.8	3.90	73.0	4.00	72.6	4.00	24.7	24.7	23.1	23.7	22.7	22.7

the vat system from 136°F (Vat 1) to 126°F (Vat 2) to 117°F (Vat 3) i.e., there was an approximate 10°F temperature drop from one vat to the next. From discussion to follow, it will be seen that this temperature drop across the vat system evidently had marked effects on color, texture and drained weight of the ginger. Overnight the temperature of the vat syrups was allowed to drop to an equilibrium 100°F in order to avoid excessive inversion of sucrose in the syrup.

Texture and color. Ginger from Vat 1 (at the highest temperature) had a dark golden color, while Vats 2 and 3 produced ginger of a pale golden to cream color. Ginger from Vat 3 was too firm compared with commercially processed ginger, while Vat 1 ginger was very similar in texture and general appearance to the commercial product. Thus the desired golden color, with a relatively soft "chewy" texture as well as good syrup absorption was only attained at the higher vat temperatures during the 4-day processing.

pH. pH control was good throughout the 4-day processing (Table 2), and required no correction after the preliminary syrup standardization to pH 4.00 with tartaric acid.

Flowrate (ml syrup/min). Syrup flow was continuous by day but ceased overnight. Flow rate of syrup through the vats decreased on successive days (Table 1a) owing to the rising syrup T.S.S. and viscosity from the first to the fourth day, and the initial high viscosity of the concentrated syrups each morning when cold (100°F).

Although the flow rate decreased from the first to the fourth day, the series arrangement of the vats made syrup flow rate through each vat on each day the same. It appears that syrup flow rate in this vat system, was not a contributing factor to differences in processing characteristics of the ginger from Vat 1 to Vat 3, although a continuous flow rate did maintain a steady concentration gradient in each vat.

Percent weight increase. Owing to the small capacity of each vat (approximately 3 L, holding 2½ lb diced ginger) practical errors were incurred in the estimations of percent weight increase as compared with the commercial scale determinations. However, trends could be determined, percent weight increase values being as follows:—

Vat 1, 18.8%; *Vat 2,* 18.8%; *Vat 3,* 16.3%.

Values of percent weight increase again indicated that the lower temperature of Vat 3 (Table 1a) had produced a lower rate of syrup absorption by the ginger, with consequent decrease in weight gain, although the lower final syrup concentration in Vat 3 was also a contributing factor.

Sucrose/RS Ratios. In comparing corresponding sucrose:reducing sugar ratios for evaporator concentrate syrup and vat system exhaust syrup (Table 2), the uniform absorption behavior of the ginger charge during processing becomes evident.

Throughout the 4-day processing, there was a general decrease in sucrose:RS ratio of the vat syrup with TSS rise from 30 to 75 TSS, which was probably an overall result of the elevated temperatures of the evaporator syrup during the syrup concentration.

In order to process ginger by syruping in a 3-vat system, a 4-day syruping process would be satisfactory, provided the temperature in each vat was maintained between 125° and 135°F in order to achieve satisfactory syrup absorption, weight gain and desirable color and texture. Continuous flow rate of syrup through the vat system seems desirable in order to maintain a steady concentration gradient and minimize possible sucrose inversion during syrup concentration.

Six-vat system. A six-vat system was investigated, using the same processing system as outlined in Fig. 1 for the three-vat system. In order to minimize sucrose inversion, syrup concentration was carried out under vacuum at 120°F, and the evaporator concentrate to the vat system then heated to an average 177°F by heat exchanger to achieve an average temperature 159°F in Vat 1 and satisfactory temperatures in the other five vats.

Percent T.S.S. Response by the ginger in each vat to T.S.S. rise in the syrup by day was progressively slower from Vat 1 to Vat 6 (Table 3). Overnight standing resulted in a much smaller reduction in T.S.S. in Vat 1 than in Vat 6.

As the syrup passed from vat to vat, the T.S.S. value fell, due to absorption of the sugar by the ginger and release of water by the ginger in each vat. From a T.S.S. value of 76.2% for the final evaporator concentrate, there was a progressive reduction in T.S.S. after final processing from 73.0 in Vat 1 to 68.8 in Vat 6. It could be assumed that at equilibrium the T.S.S. value of the ginger was the same as the syrup. The absorption of sugar by the ginger during syrup concentration therefore progressively decreased from Vat 1 to Vat 6. It will be noted also (Table 4c) that the reducing sugar of the ginger averaged 27.8% in Vat 1 and only

Table 2. Three-vat system—processing characteristics.

Hours of syruping	Evaporator syrup					Vat 1		Vat 2		Vat 3		Exhaust syrup				
	TSS	pH	R.S.	Sucrose	Sucr:RS ratio	TSS	pH	TSS	pH	TSS	pH	TSS	pH	R.S.	Sucrose	Sucr:RS ratio
0.0	—	—	—	—	—	30.0	4.10	30.0	4.10	30.0	4.10	—	—	—	—	—
2.0	28.4	4.10	8.4	20.0	2.38	27.9	4.12	27.9	4.12	27.4	4.15	27.4	4.16	7.8	19.6	2.11
4.0	34.3	3.68	10.6	23.7	2.24	33.9	3.68	32.7	3.65	31.2	3.65	30.6	3.65	9.7	20.9	2.15
20.0	—	—	—	—	—	31.0	3.85	30.2	3.80	28.3	3.85	—	—	—	—	—
23.5	44.5	3.98	14.2	30.3	2.13	43.6	3.95	41.6	3.90	41.0	3.90	41.1	3.90	12.9	28.2	2.19
27.0	47.3	3.98	15.3	32.0	2.09	47.4	3.98	47.4	3.98	47.3	3.98	47.3	3.98	15.4	31.9	2.07
44.0	—	—	—	—	—	47.0	3.85	46.6	3.85	45.6	3.88	—	—	—	—	—
47.5	60.8	3.92	19.5	41.3	2.12	59.9	3.92	59.6	3.92	57.9	3.90	58.8	3.90	18.8	40.0	2.13
50.5	66.4	3.90	21.5	44.9	2.09	65.5	3.88	64.0	3.88	64.0	3.86	64.3	3.90	20.7	43.6	2.11
68.0	—	—	—	—	—	63.4	3.85	62.7	3.82	61.9	3.82	—	—	—	—	—
71.0	74.1	3.98	24.5	49.6	2.02	73.9	3.98	73.8	3.98	73.3	3.98	72.8	4.06	24.3	48.5	2.00
76.0	75.0	3.90	25.7	49.3	1.92	75.1	3.98	74.9	3.95	74.7	4.00	74.6	3.90	25.0	49.6	1.98
150.0	—	—	—	—	—	74.8	3.90	73.0	4.00	72.6	4.00	—	—	—	—	—

Table 3. Six-vat system—processing characteristics.

	Evaporator syrup					Vat syrups												Exhaust syrup				
						1		2		3		4		5		6						
Hours of syruping	TSS	pH	R.S.	Sucrose	Sucr:RS ratio	TSS	pH	TSS	pH	TSS	pH	TSS	pH	TSS	pH	TSS	pH	TSS	pH	R.S.	Sucrose	Sucr:RS ratio
0.0	—	—	—	—	—	30.0	4.00	30.0	4.00	30.0	4.00	30.0	4.00	30.0	4.00	30.0	4.00	—	—	—	—	—
4.0	44.3	4.05	15.4	28.9	1.88	43.8	4.06	43.8	4.02	43.4	4.00	42.7	4.05	42.3	4.05	42.2	4.05	41.3	4.05	14.2	27.1	1.91
20.0	—	—	—	—	—	42.7	4.00	41.2	4.00	40.3	4.05	39.1	4.02	37.7	4.06	36.5	4.08	—	—	—	—	—
27.0	60.0	3.95	21.9	38.1	1.74	59.1	3.95	56.4	3.95	54.4	3.95	54.9	3.95	53.8	3.95	53.4	3.95	53.4	3.98	19.2	34.2	1.78
44.0	—	—	—	—	—	58.0	3.98	56.3	3.98	53.9	3.95	52.9	3.95	52.4	3.95	51.9	3.95	—	—	—	—	—
50.5	67.9	3.92	24.9	43.0	1.73	66.4	4.00	66.0	3.95	65.5	3.95	65.4	3.95	65.2	3.95	64.9	3.95	64.8	3.92	23.8	41.0	1.72
68.0	—	—	—	—	—	66.2	3.98	65.7	3.95	65.1	3.95	64.1	3.95	63.4	3.95	63.4	3.95	—	—	—	—	—
75.0	76.2	3.96	27.2	49.0	1.80	72.4	3.95	71.5	3.90	70.8	3.92	70.5	3.98	69.5	3.96	69.1	3.95	69.4	3.96	24.5	44.9	1.83
150.0	—	—	—	—	—	73.0	3.92	72.1	3.95	71.6	4.00	69.9	4.02	69.4	4.00	68.8	4.02	—	—	—	—	—

Table 4. Six-vat system—Summary of average values.

(a) *Control features*

Syrup evaporation					Vat syrups												Exhaust syrup					
					1		2		3		4		5		6				Flow rate (ml/min)			
PFT	PVT	PVP	T	pH	T	pH	T	pH	T	pH	T	pH	T	pH	T	pH	T	pH	Day 1	Day 2	Day 3	Day 4
109	140	200	120 177*	3.98	159	3.92	148	3.95	136	4.00	125	4.02	115	4.00	105	4.02	99	4.00	285	250	250	62

* 177°F = Temperature of syrup ex. heat exchanger, before entering Vat 1.

(b) *Analyses on syrups immediately after processing*

Evaporator syrup				Vat syrups																	
				1			2			3			4			5			6		
TSS (Refr)	pH	T	R.S.	TSS	pH	T	TSS	pH	T	TSS	pH	T	TSS	pH	T	TSS	pH	T	TSS	pH	T
76.2	3.96	120 177	27.2	72.4	3.95	159	71.5	3.90	148	70.8	3.92	136	70.2	3.98	125	69.5	3.96	115	69.1	3.95	105

(c) *Analyses (after 2 days) at equilibrium*

Vat contents	Vat 1			Vat 2			Vat 3			Vat 4			Vat 5			Vat 6		
	TSS	pH	R.S.	TSS	pH	R.S.	TSS	pH	R.S.	TSS	pH	R.S.	TSS	pH	R.S.	TSS	pH	R.S.
Syrup	73.0	3.92	27.2	72.1	3.95	26.4	71.6	4.00	25.2	69.9	4.02	25.1	69.4	4.00	24.9	68.8	4.02	24.6
Ginger:																		
Inner	—	—	27.6	—	—	26.6	—	—	25.6	—	—	24.6	—	—	24.5	—	—	24.5
Outer	—	—	28.1	—	—	26.9	—	—	26.1	—	—	25.5	—	—	25.3	—	—	25.2

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Microbial Profiles of Fresh Beef

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SUMMARY

A study was made of the microbial contamination of fresh beef from the time of slaughter to retail display. Immediately after slaughtering, carcasses contained high levels of microbial contamination and moister carcass areas were the most highly contaminated. The amount of contamination increased slightly after chilling and there was a larger increase during transportation to the retail store. The logarithm of the mean counts per in.^{2} from the areas sampled was 4.70 after slaughter, 4.78 prior to shipment from the plant and 5.94 on arrival at the retail store.

Small seasonal and weekly variations were observed in initial carcass contamination. However, larger differences were noted in microbial populations among various lots of cattle.

The logarithm of the mean wet shroud population per in.^{2} was 4.64. This level of contamination was slightly below the initial level of contamination on the carcasses.

The average internal temperature of the round immediately after slaughter was 102°F. After chilling for approximately 18 hr the average internal temperature of the round decreased to 61°F and immediately prior to shipment the temperature averaged 43°F. The chilling cooler fluctuated from 32–50°F, with an average temperature of 38°F. The holding cooler at the retail store was maintained at an average temperature of 38°F, while the cutting room was held at 55°F.

The predominant microorganisms present on carcasses at the packing plant were *Pseudomonas fragi, P. geniculata* and *Micrococcus luteus*. *P. fragi* and *P. geniculata* were the predominant organisms present on carcasses, loins and steaks at the retail store.

INTRODUCTION

The growth of microbes on meat is one of the main factors that causes discoloration and spoilage. Previous research (Ayres, 1955; Empey *et al.,* 1934, 1939a,b; Haines, 1931, 1933a,b; Haines *et al.,* 1933; Scott, 1931) has shown that the initial invasion of microbes occurs at slaughter and continues throughout the various processes related to preparing the meat for consumption. Haines *et al.* (1934) and Empey *et al.* (1939a) reported that fresh meat must be chilled as rapidly as possible to prevent growth of mesophilic microorganisms. Prescott *et al.* (1931) reported that in an environment of high relative humidity and insufficient air exchange, some microbes gave rise to disagreeable odors and slime formation.

Microbial contamination as related to retail processing and packaging was studied by Voegeli *et al.* (1953). Meat trays, cooler walls, band saws, slicers, blocks and knives were all reported to be highly contaminated.

Early investigators (Empey *et al.,* 1934, 1939a,b; Haines, 1933a,b; Jepsen, 1947) reported that a large percentage of the bacteria found on refrigerated fresh meat were of the genus *Achromobacter.* In 1948, the classifications of *Pseudomonas* and *Achromobacter* were changed, and since that time most researchers have reported Pseudomonas to be the principal genus found on fresh meat (Ayres, 1960; Brown *et al.,* 1958; Halleck *et al.,* 1958; Kirsch *et al.,* 1952; Marriott, 1965; Stringer, 1966).

The specific objectives of this study were to: (1) survey the microbial growth on beef carcasses from the time of slaughter until retail display, (2) survey the microbial contamination of the environment and equipment with which the meat comes in contact during slaughter and processing, and (3) identify the organisms present during the various phases of storage and processing.

EXPERIMENTAL PROCEDURE

Packing plant study. Investigations were made into the nature, extent and sources of microbial contamination of beef carcasses in a major packing plant from the time of slaughter until the carcasses were shipped from the plant. Carcasses ranged in weight from approximately 450 lb to 650 lb.

One hundred eighty carcasses were sampled immediately after slaughter and again after approximately 18 hr of chilling. Two hundred twenty similar carcasses were sampled immediately before being shipped from the packing house to the retail store. The age of these carcasses post-mortem was 2 to 4 days. After chilling, carcasses were held in a 34–36°F cooler until they were shipped by refrigerated transport to the retail store. A minimum of 10 carcasses were sampled each day of the week.

Five areas of each carcass were sampled by using the swab technique for microbial analysis. These were: (1) inside of the neck, (2) chine bone area, (3) clod area, (4) lean surface above the aitch bone and (5) the outside fat cover on the round.

In sampling, a sterile cotton swab was moistened in a test tube containing 5 ml of 0.1% peptone solution. A 2.5 sq in. sterile aluminum template was used in swabbing the areas. Appropriate dilutions were transferred to Petri dishes, poured with Standard Methods Plate Count Agar, and incubated at 70°F for 72 hr. The bacterial counts were reported as the number of organisms per in.^{2} of surface area.

Microbial contamination was determined on the shrouds, floors and walls. The shrouds used were made of a cotton material and were laundered after each use. Samples were taken from the clean dry shrouds and from wet shrouds just prior to use. Samples were taken from the shroud water after shrouds had been soaked in the water. The floors and walls were sampled at various locations throughout the plant. Samples were obtained during the chilling period, after chill and during the holding period. The samples were then plated, incubated and reported as previously described. The shroud water samples were reported as the number of microorganisms per ml.

Air counts were determined by exposing 100 × 15 mm Petri dishes poured with Standard Methods Plate Count Agar for a 10 min interval at various locations throughout the coolers midway between the floor and the

Table 1. Microbial counts on beef carcasses immediately after slaughter.

	Log per in.^{2} of surface					
	Summer [1]		Winter [2]		Total [3]	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Inside of neck	4.48	1.60–5.78	4.88	1.70–6.38	4.68	1.60–6.38
Chine bone area	4.24	1.90–5.42	4.82	1.78–6.38	4.54	1.78–6.38
Exposed area of clod	4.78	2.45–6.29	4.69	1.90–6.08	4.74	1.90–6.29
Exposed muscle above aitch bone	4.85	2.48–6.29	4.72	1.85–6.08	4.82	1.85–6.29
Fat on outside of round	4.08	1.90–6.19	4.07	1.70–5.20	4.08	1.70–6.19

[1] One hundred twenty carcasses were sampled during the summer months in two groups of 60 on two different weeks.
[2] Sixty carcasses were sampled during the winter month.
[3] One hundred eighty carcasses were sampled in three groups of 60 on different weeks.

Table 2. Microbial counts on beef carcasses of different lots of cattle immediately after slaughter.

		Log $\bar{x}$ per in.^{2} of surface					
Lot [1]	No. of carcasses	Round	Neck	Chine	Clod	Lean above aitch bone	Total
1	10	2.94	2.92	3.18	4.49	3.73	4.30
2	10	3.31	3.85	4.02	4.62	4.03	4.86
3	10	3.75	4.38	3.98	4.54	4.43	4.99
4	10	3.09	5.20	3.80	5.68	5.42	5.96
5	10	3.38	5.12	4.86	5.47	5.26	5.84
6	8	3.04	4.14	4.15	4.57	4.66	5.05
7	20	3.53	3.27	3.74	3.69	5.00	5.06
8	10	3.60	3.28	3.02	3.59	3.45	4.14
9	12	5.50	4.90	4.50	4.96	5.00	5.80
10	8	3.58	3.77	4.09	3.85	4.38	4.72
11	10	3.48	3.74	3.17	4.02	3.70	4.41
12	20	4.08	3.56	2.66	4.22	3.86	5.60
13	10	4.17	3.41	3.17	3.45	3.14	4.36
14	20	4.16	5.34	5.28	5.15	5.16	5.85
15	10	3.40	3.28	3.69	3.75	3.72	4.31

[1] Lots 1 through 11 were sampled in the summer months. Lots 12 through 15 were sampled in the winter months.

ceiling. The microbial counts were reported as the number of colonies per plate.

Temperatures of carcasses were recorded each day at the following periods: immediately after completion of the slaughtering procedures, after approximately 18 hr chill, and immediately before the carcasses were shipped from the plant. Temperature readings of the carcasses were made by inserting a meat thermometer (Pandux No. 134) into the thickest portion of the round. Temperatures of the various coolers were recorded throughout the plant during the study.

Cultures were isolated and identified from six representative carcasses that were sampled at each of the following times: immediately after slaughter, after 18 hr chill, and immediately before carcasses were shipped from the plant. A total of 65 cultures were identified. The cultures were isolated and classified according to methods described by Breed *et al.* in *Bergey's Manual of Determinative Bacteriology* (1948, 1957) and Klinge (1960).

Retail store study. Forty sides of beef and the loins and retail cuts from these carcasses were examined microbiologically during February, September and October. Temperatures of the carcasses, coolers and cutting rooms were also recorded.

Some of the carcasses studied at this point were from major packers other than where the plant study was conducted. The five carcass areas that were studied at the packing plant were sampled on the carcasses at the retail store plus the fat cover over the loin.

Samples were taken from the chine area and fat surface of the loin before cutting the loin into retail cuts. Steaks were selected from each loin and sampled on the surface before and after removing the smear.

Samples were taken from the band saw blade, band saw table top and cutting table top before and after the equipment had been used.

Air counts were determined by exposing Petri dishes throughout the cooler about midway between the floor and ceiling. Plates were exposed at table top height in the cutting room at the beginning, middle and at the end of the day. Bacterial counts were reported as number of colonies per plate.

The temperatures of the rounds were recorded as soon as the carcasses arrived at the store. The temperatures in the cooler, cutting room and display case were recorded for a 24 hr period with a recording thermometer.

Cultures were isolated and identified from samples of 2 representative carcasses and the loins and steaks from these carcasses at the store. A total of 31 cultures were identified. The cultures were isolated and classified as previously described.

RESULTS AND DISCUSSION

The microbial populations present on the carcasses immediately following slaughter are shown in Table 1. The areas sampled were all highly contaminated. Moister areas which come in contact with other sources of contamination—such as the neck, lean surface area above the aitch muscle, and the clod area—were the most highly contamined. The chine and round areas were least contaminated. The logarithm of the mean carcass population per in.^{2} was 4.70. These results would be expected since bacteria should multiply faster in moister areas compared to the dryer chine area.

Season had very little effect on the degree of initial contamination on the carcasses (Table 1). However, during the summer the clod and lean surface area above the aitch bone had larger counts. The inside of the neck and chine area had the highest counts in the winter. The logarithm of the mean carcass population per in.^{2} in the summer was 4.69 and in the winter it was 4.71.

Differences were noted in microbial populations among lots of cattle (Table 2). In lots with lower microbial populations, all areas were low as compared to the lots with higher populations.

A comparison of the microbial counts on the carcasses at different days of the week immediately after slaughter is shown in Table 3. The levels of contamination throughout the week were fairly constant, with the exception of a significant increase on Wednesday. The carcasses sampled on Wednesday included lots 4, 5, 9 and 14 (Table 2). These lots were more highly contaminated than any other carcasses sampled. There was no obvious reason why the contamination was higher on these carcasses. The moister areas and the areas most susceptible to contact were more highly contaminated than the dryer, less exposed areas.

Microbial counts on shrouds and shroud water revealed that the shrouds contained a large number of bacteria per in.^{2} (Table 4). After wetting the

shrouds in tap water, the counts increased to a magnitude approaching the initial level of contamination on the carcass after slaughter. The logarithm of the mean water count per ml in which the shrouds were soaked was 4.82. This indicates that the shrouds could be an important source of contamination to the carcass. However, no tests were made to determine if shrouds contained the same microorganisms found on the meat.

The microbial levels on the chilled carcasses are shown in Table 5. The chilled carcasses contained slightly larger numbers of organisms compared to hot carcasses immediately after slaughter. The logarithm of the mean carcass count per in.^{2} after chilling was 5.08. The moist areas were the most highly contaminated. The high counts on the outside fat cover may, in part, be due to contamination from shrouds during chilling.

When seasonal comparisons were made of counts from chilled carcasses, higher counts were found on the carcasses sampled in the summer (Table 5). The greatest difference was in the neck region, clod area and outside fat cover on the round. The logarithm of the mean carcass population per in.^{2} in the summer was 5.23 and 4.46 in the winter.

The microbial counts from the floors and walls during chill and after chill are presented in Table 6. The floors were more highly contaminated than the walls. The counts during the chilling period were considerably higher than at the end of an approximate 18 hr chilling period. During the chilling period, there was more contamination in the atmosphere than after chilling. Approximately a four-fold decrease was noted in the air contamination after the chilling process.

Temperature profiles of the carcasses. The carcass temperatures were checked throughout the sampling periods as they came off the kill floor by inserting a thermometer into the thickest portion of the round. Temperatures varied from 101–105°F, with an average temperature of 102°F.

The microbial counts on the carcasses by location before shipment are shown in Table 7. The logarithm of the mean carcass population per in.^{2} was 4.78. The moister areas were again the most highly contaminated. The muscle area above the aitch bone was more highly contaminated than the neck or clod area. Appreciable contamination may be attributed to the extra handling of the carcasses and to the multiplication of the low tem-

Table 3. Microbial counts of beef carcasses at different days of the week immediately after slaughter.

	Log $\bar{x}$ per in.^{2} of surface			
	Monday	Tuesday	Wednesday	Thursday
	(60)[1]	(30)[1]	(60)[1]	(30)[1]
Inside of neck	3.50	3.97	5.12	3.79
Chine bone area	3.60	3.53	4.97	3.84
Exposed area of clod	4.05	4.15	5.29	4.25
Exposed muscle above aitch bone	4.59	4.01	5.16	4.21
Fat on outside of round	3.75	3.90	4.85	3.34

[1] Number of carcasses sampled.

Table 4. Microbial counts of shrouds and water in which the shrouds were soaked.

	Log bacteria per in.^{2} of surface				Log bacteria per ml	
	Dry shroud (36)[1]		Wet shroud (41)[1]		Shroud water (14)[1]	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Counts	4.44	1.60–4.75	4.64	3.00–5.30	4.82	4.00–5.07

[1] Number in parentheses refers to the number of samples.

Table 5. Microbial counts on chilled beef carcasses.

	Log per in.^{2} of surface					
	Summer[1]		Winter[2]		Total[3]	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Inside of neck	5.14	1.78–6.65	3.58	1.30–5.20	4.97	1.30–6.65
Chine bone area	3.88	1.60–5.48	2.54	1.48–3.58	3.72	1.48–5.48
Exposed area of clod	5.09	1.78–6.75	3.23	1.60–4.85	4.80	1.60–6.57
Exposed area above the aitch bone	5.12	1.30–6.45	4.88	1.30–6.25	5.05	1.30–6.45
Fat on outside of round	5.66	1.60–7.22	4.79	1.78–6.08	5.51	1.60–7.22

[1] One hundred twenty carcasses were sampled in the summer months in two groups of 60 on different weeks.
[2] Sixty carcasses were sampled in the winter months in 1 week.
[3] One hundred eighty carcasses were sampled in three groups of 60 on different weeks.

Table 6. Microbial counts on the floors, walls and air during and after chilling of beef carcasses.

	Log $\bar{x}$ per in.^{2} of surface				Mean count per plate	
	During chill		After chill		During chill	After chill
	Floors	Walls	Floors	Walls	Airborne contamination	
	(32)[1]	(14)[1]	(39)[1]	(37)[1]	(42)[1]	(57)[1]
Counts	7.67	6.97	6.85	6.78	72	17

[1] Number in parentheses refers to the number of samples.

Table 7. Microbial counts on beef carcasses before shipment.

	Log per in.^{2} of surface					
	Summer[1]		Winter[2]		Total[3]	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Inside of neck	4.98	2.71–6.43	4.03	1.90–5.59	4.82	1.90–6.43
Chine bone area	4.77	1.90–6.59	3.42	1.60–4.90	4.60	1.60–6.59
Exposed area of clod	4.75	2.55–6.59	4.29	1.60–6.08	4.65	1.60–6.59
Exposed muscle above aitch bone	5.18	1.60–7.24	4.87	1.30–6.69	5.09	1.30–7.24
Fat on outside of round	4.48	2.20–6.20	4.19	1.60–5.96	4.40	1.60–6.20

[1] One hundred forty-five carcasses were sampled during the summer months in groups of 75 and 70 on different weeks.
[2] Seventy-five carcasses were sampled during the winter months in 1 week.
[3] Two hundred twenty carcasses were sampled in groups of 75, 70 and 75 on different weeks.

perature organisms. No significant differences were evident in microbial counts between seasons. The logarithm mean carcass count per in.[2] in the summer was 4.90 and 4.38 in the winter.

Carcasses sampled at various post-slaughter intervals before shipment showed that number of bacteria on the carcasses increased as time increased (Table 8). The logarithm of the mean carcass count per in.[2] after 1 day storage was 4.23; after 2 days, 4.77; after 3 days, 4.44; and after 4 days, 5.57. The greatest increase was on the muscle area aitch bone, with an appreciable increase noted in the neck region and external fat of the rounds.

The contamination levels found on the floors and walls in the holding cooler are shown in Table 9. The floors and walls in the holding cooler were less contaminated than those in the chill room. The contamination levels in the atmosphere may have been due to the use of sawdust on the floors.

Temperature profiles of the carcasses. The internal round temperature of the carcasses decreased from 101°F after slaughter to 61°F after chill (approximately 18 hr). The temperatures ranged from 60–63°F. There was a large fluctuation of temperatures in the cooler. The temperatures ranged from 32–50°F, with an average temperature of 38°F. Carcasses were also checked for temperature before being shipped from the plant. An average internal temperature of 43°F was found for all carcasses, with a range of 33–53°F.

The microbial counts on the carcasses upon receipt at the retail store are shown in Table 10. The carcasses acquired a significant increase in microbial numbers during transportation from the packing plant to the retail store. The logarithm of the mean carcass population per in.[2] was 5.94. The greatest increase was on the moister areas. The high levels of contamination may be attributed to more contamination through handling and changes in meat temperature during transportation. The lower levels on the chine area may be attributed to the drying of the surface area during aging which provided an undesirable medium for the organisms.

Season had an effect on the degree of contamination present on the carcasses upon receipt at the store (Table 10). The logarithm of the mean carcass populations per in.[2] in the winter was 6.35 as compared to 5.60 in the summer. The moister areas were more highly contaminated regardless of season.

Comparison of microbial counts on various areas of the carcasses after slaughter, after chill, before shipment and upon receipt at the retail store are presented in Fig. 1. The microbial populations on the neck region showed no appreciable changes after chilling and before shipment. However, an increase in microbial population was

Table 8. Microbial counts on beef carcasses at different days post-slaughter.

	Log per in.^{2} of surface							
	1 day		2 days		3 days		4 days	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
	(88)[1]		(72)[1]		(27)[1]		(11)[1]	
Inside of neck	3.92	1.78–4.99	4.89	1.90–6.39	4.19	2.50–4.98	4.44	3.38–5.10
Chine bone area	4.00	1.90–5.67	4.51	2.00–6.02	4.29	2.60–5.52	4.64	2.41–6.59
Exposed area of clod	4.59	1.78–6.08	4.84	2.20–6.59	4.35	2.38–5.22	4.22	2.60–5.22
Exposed muscle above aitch bone	3.80	1.60–5.12	4.99	1.60–6.70	4.79	1.60–6.13	6.21	1.78–7.24
Fat on outside of round	4.31	1.60–5.96	4.18	1.60–5.54	4.31	2.00–5.55	5.18	2.85–6.20

[1] Number in parentheses refers to the number of carcasses sampled.

Table 9. Microbial populations on the floors, walls and air in the holding cooler before shipment.

	Log bacteria per in.^{2} of surface		Mean count per plate
	Floors	Walls	Airborne contamination
	$\bar{x}$	$\bar{x}$	Mean
	(37)[1]	(33)[1]	(47)[1]
Counts	5.66	3.85	51

[1] Number in parentheses refers to the number of samples taken.

Table 10. Microbial populations on beef carcasses upon receipt at the retail store.

	Log per in.^{2} of surface					
	Summer [1]		Winter [2]		Total [3]	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Inside of neck	5.90	2.50–6.80	6.82	2.08–7.45	6.35	2.08–7.45
Chine bone area	4.69	1.44–6.02	5.36	1.30–5.98	4.98	1.30–6.02
Exposed area of clod	5.71	1.68–6.71	6.25	2.55–7.00	5.92	1.68–7.00
Exposed muscle above aitch bone	5.60	1.84–6.81	6.27	1.60–7.17	5.89	1.60–7.17
Fat on outside of round	5.43	1.75–6.45	5.90	1.90–6.48	5.61	1.75–6.48

[1] Twenty-nine carcasses were sampled during the summer months in groups of 12 and 17 on different weeks.
[2] Ten carcasses were sampled during the winter months during 1 week.
[3] Thirty-nine carcasses were sampled in groups of 12, 17 and 10 on different weeks.

Table 11. Microorganisms present on beef carcasses in the packing plant.

		Percent organisms present		
Genus	Species	After slaughter	After chill	Before shipment
Pseudomonas	geniculata	9.0	1.1	21.8
Pseudomonas	fragi	29.0	19.9	22.8
Pseudomonas	rugosa	2.0	8.0	3.7
Pseudomonas	fluorescens	......	......	1.9
Achromobacter	....	......	......	2.0
Micrococcus	luteus	37.0	47.7	38.5
Sarcina	lutea	8.0	8.3	......
Flavobacterium	....	2.0	......	3.3
Bacillus	cereus	2.0	......	......
Bacillus	megatherium	10.0	12.7	3.0
Aspergillus	niger	......	2.3	3.0

noted upon arrival at the retail store. A decrease in microbial population was noted on the chine area after chilling. The level of contamination was as high before shipment as the initial population. A slight decrease was noted upon receipt at the retail store.

The microbial populations on the muscle area above the aitch bone increased slightly up to the time of shipment and a greater increase was evident upon arrival at the retail store. The round was the least contaminated initially; however, fluctuations in microbial populations were noted until the time of shipment and a large increase was evident upon receipt at the retail store. The neck region, clod area and the muscle above the aitch bone contained the highest microbial counts when the carcasses were received at the store. The round was slightly lower with the chine being the least contaminated.

The types of organisms present on the carcasses throughout the plant are shown in Table 11. The predominant organisms present after slaughter were of the genera *Pseudomonas* and *Micrococcus*. The *Pseudomonas* was slightly more predominant. An appreciable number of *Bacillus* organisms were present on the carcasses immediately after slaughter. The *Micrococcus* genera increased in predominance after chill while the *Pseudomonas* decreased slightly. This is contrary to what would be expected since the *Micrococcus* are not considered to be psychrophilic. A small amount of the mold *Aspergillus niger* was present after chill. The *Pseudomonas* genera increased considerably before shipment of the carcasses.

The *Pseudomonas* and *Micrococcus* genera were predominant in both the summer and winter seasons in about the same proportions.

Microbial populations on the carcasses, wholesale and retail cuts were made at the retail store. The results in Table 10 indicate that the microbial populations on the carcasses upon arrival at the retail store had increased significantly during shipment.

After the carcasses were sampled, the short loins were removed from the sides for further sampling. The fat cover on the loins before cutting into the retail cuts contained a logarithm of the mean population per in.^{2} of 5.10 and the chine areas contained 5.59.

The microbial populations on the unscraped and scraped steaks immediately after cutting are presented in Table 12. An appreciable amount of contamination was transferred to the steaks through the cutting procedures.

The microbial population levels found on the saw and cutting table at the retail store are shown in Table 13. The "clean" saw blade was highly contaminated. The bacterial counts increased considerably when the blade became soiled by the cutting of the meat product. Large populations were

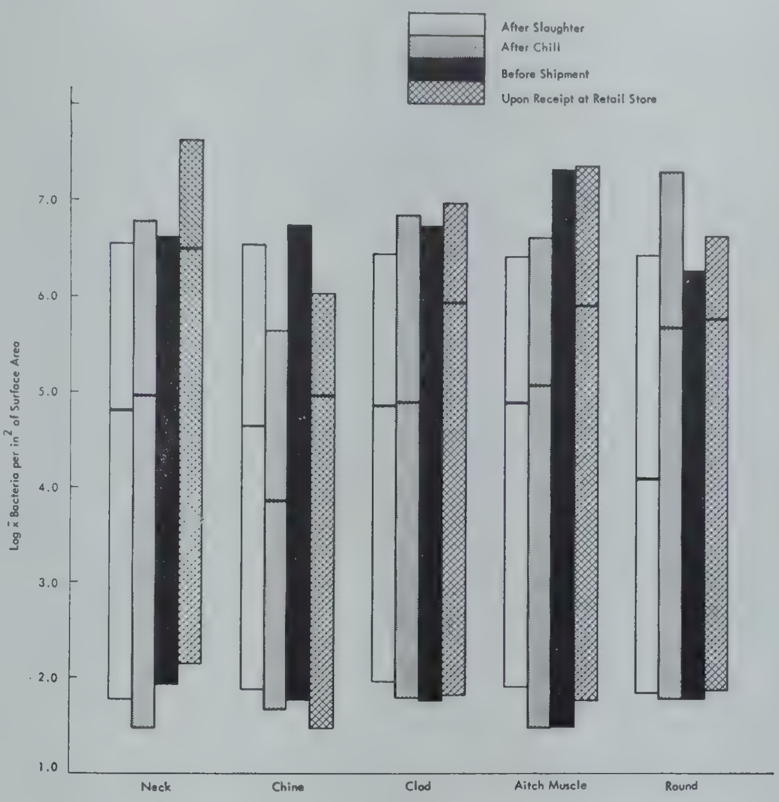

Fig. 1. Comparison of the microbial counts on various areas of the carcass after slaughter, after chill, before shipment and upon arrival at the retail store.

Table 12. Microbial population on beef steak.

	Log bacteria per in.^{2} of surface area			
	Unscraped steaks		Scraped steaks	
	$\overline{x}$	Range	$\overline{x}$	Range
	(38)[1]		(38)[1]	
Counts	4.41	0.78–5.42	3.71	1.30–4.34

[1] Number in parentheses refers to the number of steaks sampled.

Table 13. Microbial populations on equipment and air in the coolers and cutting room at the retail store.

	Number of samples	Log $\overline{x}$ bacteria per in.^{2}	Mean bacteria count per plate
Cleaned saw blade	13	3.28	....
Soiled saw blade	13	3.70	....
Clean saw table top	13	4.12	....
Dirty saw table top	13	4.14	....
Dirty wooden table top	7	4.27	....
Airborne contamination in the cooler	20	......	28
Airborne contamination in the cutting room			
Beginning of day	10	......	8
Middle of day	10	......	26
End of day	10	......	28

Table 14. Microorganisms present on beef carcasses, loins and steaks at the retail store.

Genus	Species	Percent organisms present		
		Carcasses	Loins	Steaks
Pseudomonas	fragi	54.4	61.5	64.7
Pseudomonas	geniculata	30.9	11.6	16.9
Pseudomonas	fluorescens	5.4	......	9.1
Achromobacter	....	9.3	26.9	10.3

found on the saw table top and the wooden cutting table tops which came in contact with the meat. The atmosphere in the cooler also contained some microorganisms. Bacteria in the air may add contamination to the carcasses and cuts as well as the equipment. The cutting room was nearly free of contamination at the beginning of the day. Air contamination increased approximately three-fold as the working day progressed. At midday the air contamination was at its maximum.

Temperature profiles of carcasses, coolers, and cutting room. Avg. temperature of carcasses upon receipt at the retail store was 38°F. A range in temperature of 36–40°F was noted. The average temperature of the cooler was 34°F, with a range of 30–40°F. The fluctuation in temperature may be caused by the opening and closing of the cooler doors during deliveries and during the cutting operations. The cutting room was maintained at an average temperature of 55°F.

Cultures from randomly selected carcasses, loins and steaks at the retail store were isolated and identified (Table 14). *Pseudomonas fragi* were the most predominant organisms present on carcasses upon receipt at the retail store. *Pseudomonas geniculata, Pseudomonas fluorescens* and *Achromobacter* appeared in appreciable quantities. *Pseudomonas fragi* and *Achromobacter* were predominant on the loins. *Pseudomonas fragi* was predominant on the steaks. It is interesting to note the absence of *Micrococci* at the retail store level since this genus was present on the carcasses at the plant. This could be due to the extended period of exposure to a temperature low enough to retard growth or perhaps kill the cells.

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• In the words of the English philosopher John Ruskin:

Quality is never an accident. It is always the result of intelligent effort. There must be a will to produce a superior article.

• Superior articles is what we would like to see in the *Research* section of Food Technology. Prospective authors are invited to request from the Scientific Editor IFT's "Style Guide for Research Papers" that may help put their article in the mold at least of acceptable form.

Determining the Emulsifying and Emulsion Stabilizing Capacity of Protein Meat Additives

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SUMMARY

A method is described to evaluate the emulsifying and emulsion stabilizing activity of protein meat additives. Practical results with four different additives, obtained under normal commercial processing conditions, served as a basis for developing the method.

The four additives studied were: two brands of isolated soy protein, sodium caseinate and a soy concentrate.

The influence of several variables in the described method, such as dispersion time of the protein, quantities of water, oil and protein, temperature, variation in the manufacture of the emulsion, were studied.

The results obtained with the proposed method are generally in agreement with those obtained in sausage manufacture, as far as fat separation is concerned.

INTRODUCTION

Several workers, Swift *et al.* (1961, 1963), Swift (1965), Carpenter *et al.* (1964), Trautman (1964), Pearson *et al.* (1965), Hansen (1960), Hegarty *et al.* (1963), Christian *et al.* (1967), have tried to develop a model system for laboratory determination of the comparative emulsifying capacity of meat proteins.

Rongey (1965) suggested a method for the determination of sausage emulsion quality. Hudspeth *et al.* (1967) tried to apply these methods to practical problems.

Given the numerous variables in the production of an emulsion in actual practice (*e.g.* a sausage), it will be very difficult to develop a laboratory method that has a one-to-one correlation with actual practice.

However, it should be possible to develop a model that gives an answer to the question: is protein *A* superior, equal or inferior to protein *B*, in emulsifying and emulsion stabilizing properties. It should be possible also to apply the answer to most practical applications.

The methods proposed do not meet this latter condition. Pearson (1965) found sodium soy proteinate (Promine D, Central Soya Co. Inc., Chicago, Ill.) to be a poor emulsifier in the usual pH range of meat and suggested that it probably does not serve any major function in emulsifying fat when added to sausage products.

We could not confirm this statement with actual sausage production tests in which this soy proteinate was compared with sodium caseinate (Table 1). We tried to develop a model system the other way around.

Table 1. Influence of protein meat additives on fat separation in actual sausage production.

Sausage formulation, luncheon meat type:

Frozen lean beef	30%
Frozen pork head meat	15%
Cooked skins	5%
Water	15%
Soft pork fat	25%
Cured ham trimmings	10%

Additives per kg sausage batch:

20 grams	sodium chloride, with 0.6% admixed sodium nitrite
1 gram	dextrose
4 grams	mixed dry spices
0.5 gram	sodium ascorbate

Results

Batch	Protein additive	Fat separation
1	—	8.2%
2	2% Promine D	0.4%
3	2% Sodium caseinate	2.3%
4	2% IPSO	0.3%
5	2% Promosoy	7.9%

The sausages were heated at 110°C in cans, during 70 min. The mass was produced in a bowl chopper, type Krämer & Grebe, with knives revolving at 3560 rpm, and revolving time of the bowl 1.9 sec.

Given the results with sausages, made in different factories in different countries, we were able to make a statement regarding the emulsifying capacity and stability of the following four different types of non-meat proteins:

A. An isolated soy protein (IPSO, Vaessen Schoemaker Iberica, Barcelona, Spain)

B. An isolated soy protein (Promine D, Central Soya Co. Inc., Chicago, Ill.)

C. A sodium caseinate (Behrens, Hamburg)

D. A soy protein concentrate (Promosoy, Centrol Soya Co. Inc., Chicago, Ill.)

Our requirement for a model test was that its results should be the same as those found in actual practice.

METHODS

Definition of the protein. Protein was determined according to standard Kjeldahl procedure: ash by heating the sample to constant weight at 600°C; moisture by toluene distillation; and pH with a glass electrode on a Philips pH meter 9403/01, in a 1% dispersion.

The N.S.I. was determined by weighing exactly 2.5 g protein, adding 100 ml water, and stirring for 1 hr at a controlled temperature of 50°C. The solution was then centrifuged for 30 min at 3,000 rpm. The surfactant was poured into a 250 ml volumetric flask. The extracting procedure was repeated on the residue, and this was added to the 250 ml volumetric flask and made up to volume. If the liquid was not clear, it was filtered. Then 100 ml of the liquid was pipetted into a Kjeldahl bottle and the N was determined. It was also determined if the N was of the original sample.

$$NSI = \frac{\text{Water Soluble Protein}}{\text{Total Protein}} \times 100.$$

With these analytical procedures, the protein to be studied is defined.

Determination of the emulsion stability (E.S.). Weigh accurately 5 g of the sample and disperse it with stirring in 90 ml distilled water at 15°C in a 600 ml beaker for 15 min.

Stop stirring and add 3 g of NaCl. Resume stirring for 1 min. Add from a burette in 5 min 50 g soybean oil of 15°C to the dispersed protein while stirring at 1,000 rpm. When all the oil is added, continue to stir for one more minute.

Pour the contents of the beaker into a 150 ml graduated centrifuge tube (Fig. 1). Put the centrifuge tube into a water bath kept at 85°C for 15 min.

Stir the contents of the tube very slowly. After heating 15 min, cool the tube under running tap water for 15 min. Centrifuge for 15 min at 3,000 rpm.

Read off the amount of oil separated, and repeat centrifuging until the vol-

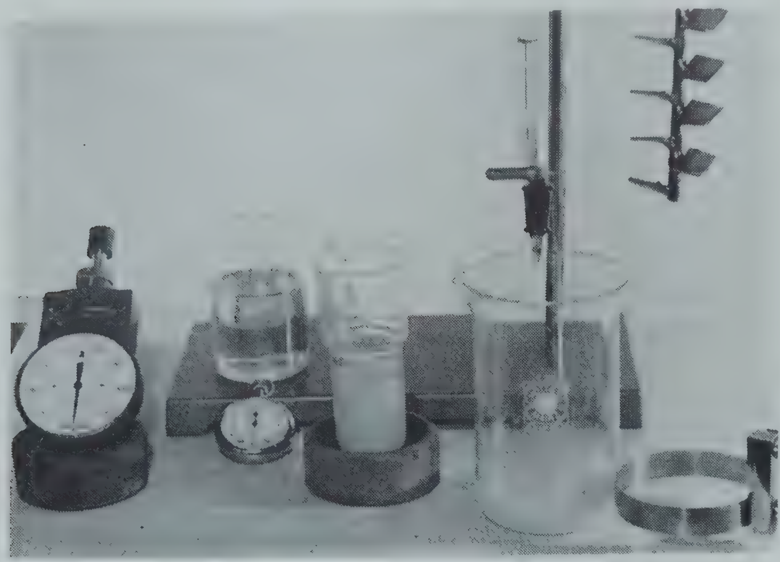

Fig. 1. Apparatus for determination of E factor. Left to right: tachometer, stopwatch, beaker with oil, centrifuge tube calibrated, 600 ml beaker with dispersion, buret, stirrer.

ume of separated oil does not change any further. Normally two times 15 min is sufficient. Calculate the separated oil as a percentage of the total amount of oil added.

Influence of several important variables. *Dispersion time.* Several emulsions were made according to the above procedure with dispersion time varying from 1 to 40 min. Fig. 2 shows that the maximum dispersion in this system is reached after about 10 min.

Variable quantity of water. Fig. 3 shows that changing the quantity of water with a constant amount of protein and oil has a large influence on oil separation.

A certain amount of protein does not give the maximum possible dispersion if the quantity of water is too low. The amount of water should be such that it does not limit the potentially available quantity of dispersible protein.

When between 80 ml and 100 ml water was added the curve of the oil separation leveled off. As a result we dispersed 5 g of protein in 90 ml distilled water as a standard procedure.

Amount of oil. The results of this variation are given in Fig. 4. In these tests 90 ml of distilled water + 5 g of protein were used. It seems quite remarkable that the amount of oil separation becomes less, the more oil is added. If the amount of oil is still more increased a phase inversion will occur. Up till the point of phase inversion one observes an increase of the viscosity of the emulsion. This viscosity increase stabilizes the emulsion (Becher, 1965).

The amount of fat as compared to the amount of water in a sausage, however, is not so high that a viscosity increase can occur. If one evaluates protein meat additives for sausage production one should try to use a water/oil ratio as it is in an actual sausage, and eliminate the influence of the viscosity increase on the stability of the oil in water emulsion.

Amount of protein. The influence of this variable was investigated with two different kinds of proteins, an isolated soy protein and a sodium caseinate. Fig. 5 shows the results. With a given amount of water and oil, the stability of the emulsion is greater, with a larger amount of protein, a result which is in accordance with actual practice.

Temperature and time. The proteins used in these tests show the distinct influence of temperature above 70°C on the oil separation. In accordance with actual practice for pasteurizing sausages, we fixed the temperature of the water bath at 85°C. The temperature should be kept constant, variations in the temperature having a considerable influence on the amount of oil separation (Fig. 6). The time, however, during which the centrifuge tube is kept at a certain temperature is less important.

Fig. 6 shows that the temperature curve levels off quicker while slowly stirring the contents of the tube, which means that the emulsion is kept longer at a constant temperature. After a certain time, the temperature of the stirred and nonstirred contents of the centrifuge tube reaches the same value.

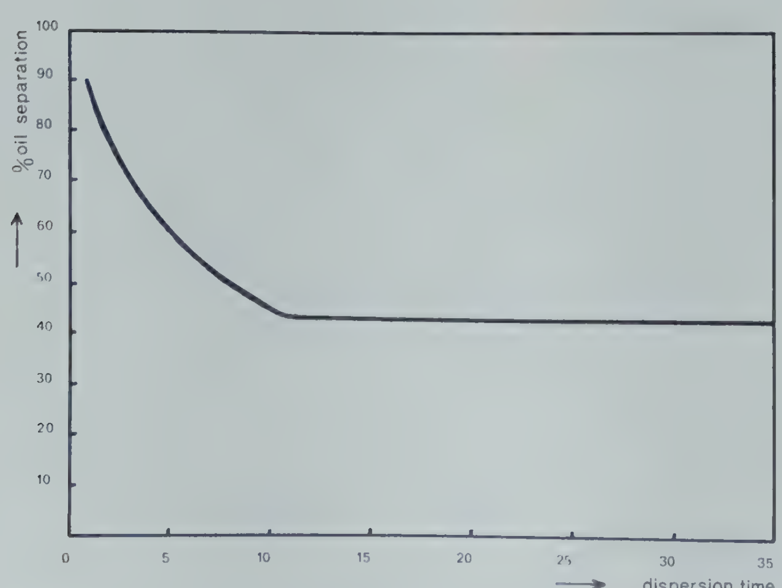

Fig. 2. Influence of dispersion time on the amount of oil separation.

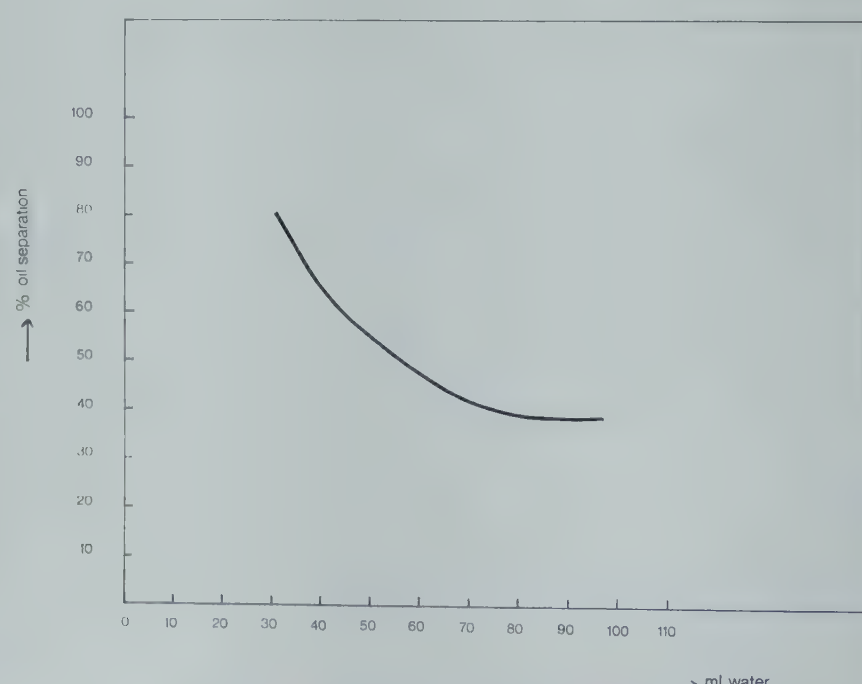

Fig. 3. Influence of the amount of water on oil separation.

The amount of oil separation in both cases is, however, the same.

This is in accordance with actual practice: temperature is more important than time, which means no *more* fat separation, if the temperature gradient does not change any more.

The emulsification procedure. This is the most important variable. When we made an emulsion in an Ultra Turrax apparatus at 10,000 rpm we got a stable emulsion under the conditions of the test, without any protein addition. On the other hand, by stirring slowly with a glass rod we got 100% oil separation even with a large protein addition.

Size and form of the beaker also influence the test results. As a standard we use a 600-ml beaker with I.D. of 78.3 mm, and a height of 140 mm. The stirring apparatus is shown in Fig. 1.

The rpm also influences the amount of oil separation to a large extent (Table 2).

RESULTS AND DISCUSSION

The non-meat proteins added to the cutter are only one of a large range of variables in sausage production.

We took several proteins of which we knew the general behavior as fat stabilizers in sausages from practical experience.

We obtained a ranking order of these

Table 2. Influence of the amount of rpm on the emulsion stability (Every figure is the mean of 5 determinations).

R.P.M.	Oil separation
750	97%
1,000	82%
1,250	64%

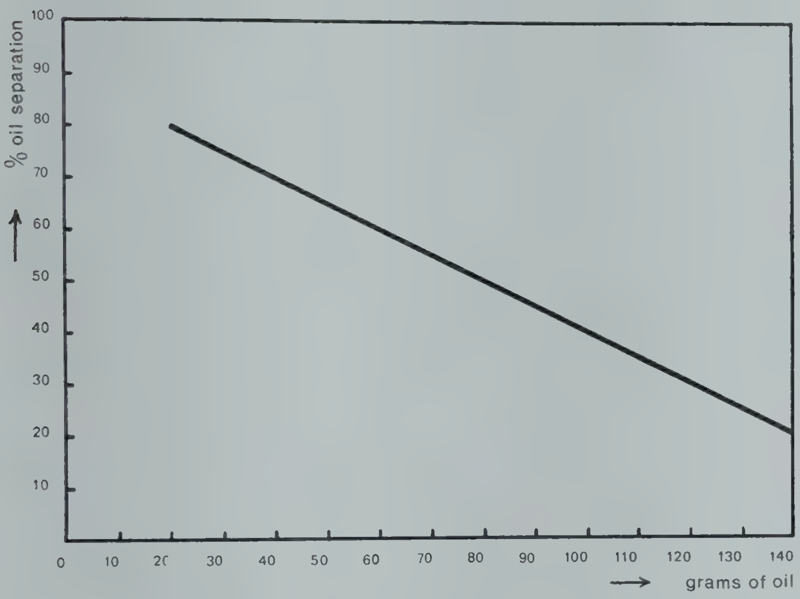

Fig. 4. Influence of the amount of oil on oil separation.

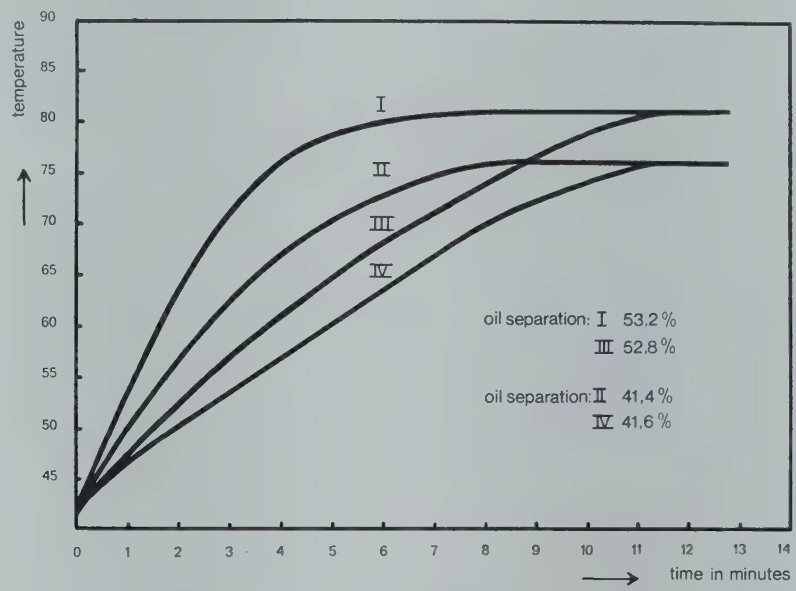

Fig. 6. Temperature-time curves. I. waterbath at 85°C, contents of the tube stirred; II. waterbath at 80°C, contents of the tube stirred; III. waterbath at 85°C, contents of the tube not stirred; IV. waterbath at 80°C, contents of the tube not stirred.

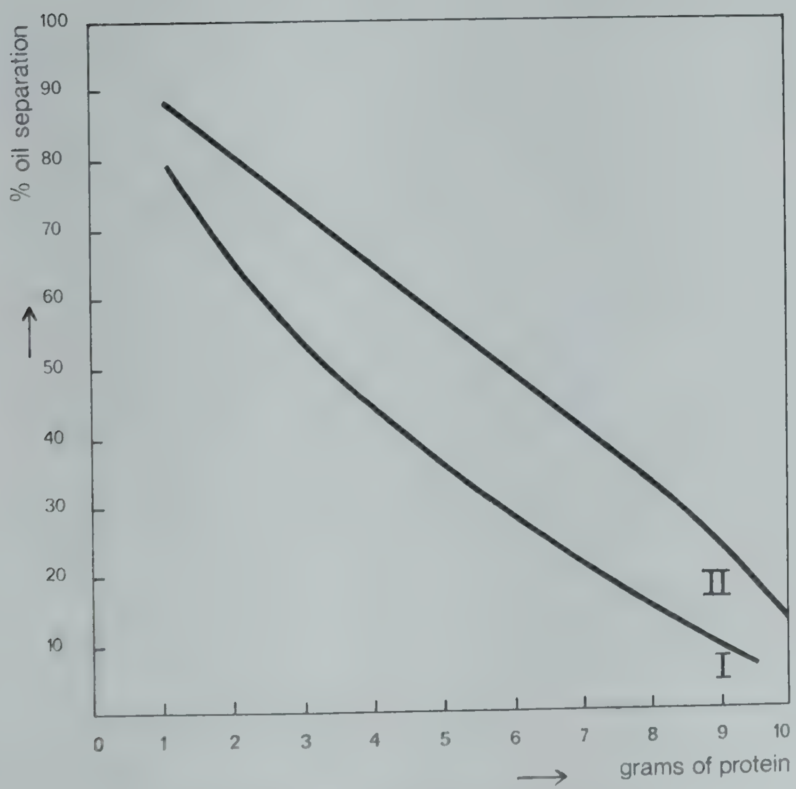

Fig. 5. Influence amount of protein on oil separation. I. isolated soy protein, II. sodium caseinate.

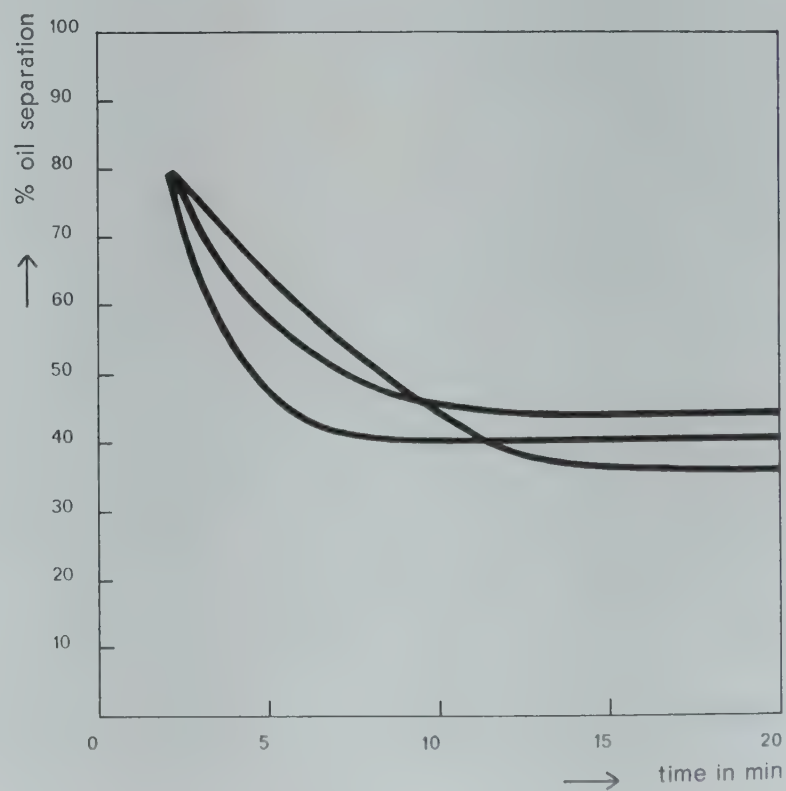

Fig. 7. Differences in dispersion time of three different batches of an isolated soy protein.

Table 3. Chemical analysis of four proteins used in determination of emulsion effectivity.

	A	B	C	D
Moisture	3.3%	4.8%	6.0%	5.1%
Nitrogen	13.9%	14.0%	14.1%	10.4%
Protein	87.0%	87.6%	88.2%	64.0%
W.S.P.	74.1%	72.4%	86.3%	6.9%
N.S.I.	85.2%	82.7%	97.8%	10.8%
Ash	4.7%	4.0%	4.9%	7.4%
pH 1% dispersion	7.2	7.6	6.9	7.2
% oil separation	42.4%	42.7%	54.5%	96.8%

A—IPSO, an isolated soy protein (IPSO, Vaessen Schoemaker Iberica, Barcelona, Spain)
B—Promine D, an isolated soy protein (Central Soya, Chicago)
C—Na caseinate, a milk protein (Behrens, Hamburg)
D—Promosoy, a soy concentrate (Central Soya, Chicago)
Each determination in 5-fold.

Table 5. Influence of emulsion temperature on oil separation of two different proteins (Dispersion time in all cases 60 min. Each determination in five-fold).

Temperature	% oil separation A	% oil separation C
5°C	51.2	55.6
10°C	44.6	54.8
15°C	43.4	54.2
20°C	48.6	50.8

proteins A, B, C and D, meaning that either A gave less fat separation than B, or that A could be used in a lesser amount than B for equal performance, as far as fat separation was concerned. Table 3 shows the characteristics of these four proteins.

From a very large amount of batches over several years in a great number of factories in different countries we came to the conclusion that: A was in most factories equal to B; in some factories, A was preferred because of less fat separation than B; in other factories the reverse happened. A and B were generally preferred to C. D had only a very slight effect as a fat stabilizer.

Summarizing, A = B; C less than A and B; D clearly less than A, B and C. The results of the emulsion tests of these four proteins are shown in Table 3. The similarity of these test results and the practical experience (Table 1) is very close.

As we wanted to have an idea about the reproducibility of the method, we determined the oil separation of A and C in 10-fold. The standard deviation with protein A was $S_A = 1.1$, with protein C, $S_C = 1.2$. It is well known that protein must be added as early in the chopping process as possible. When added at the end of the process, the effectiveness is very low. We made an emulsion of oil in water with salt and added the protein after the emulsion was formed. Stirring was continued for 1 min. After this treatment the amount of oil separation was 96.8%, as compared to 42% when using the protein in the right way, *i.e.,* first making a dispersion.

This laboratory result confirms the results in actual practice. The emulsifying capacity of a sample of fish protein was determined. The NSI was 2.6. All the added oil separated.

We conclude that the fish protein in this form is not suitable as an emulsifying agent in the manufacture of sausages.

The N.S.I. of a soy protein becomes higher at a higher pH. Therefore we could expect a smaller amount of oil separation at a higher pH. Table 4 shows the results of this test as done with Protein A.

Table 4. Influence of the pH on the amount of oil separation (Each determination in 5-fold).

pH	% oil separation
7.0	42.9
7.4	40.7
7.8	37.6

The dispersion of the protein in water was brought up to the required pH with NaOH. A higher pH gives a lower amount of oil separation. The dispersion of the protein in water was done in all the tests for 15 min. Compared to the actual time in a bowl chopper, these 15 min are much too long.

There is, however, a large difference between the laboratory stirrer and the knives of a bowl chopper. One can imagine that the dispersion time of a protein depends on the kind of bowl chopper used. One may also expect, in practice, a variation in dispersion time, using different types of bowl choppers. On the other hand, given a certain bowl chopper, one could be interested in knowing if a certain non-meat protein does disperse quicker than another one. The dispersion time of different types of non-meat proteins, or perhaps slight batch-to-batch variations in one type of a non-meat protein can be measured easily by a variation of the dispersion time in the test as described.

Fig. 7 shows the results of such a test of three different batches of an isolated soy protein. Quite often a sudden occurrence of fat separation in a factory can be traced to a variation in dispersion velocity. The remedy is obvious: a slight increment in chopping time. The dispersion in water of the protein in all the tests mentioned has been done at 15°C. In practice the temperature of the contents of the bowl chopper varies between about 5°C and 20°C, at the end of the chopping.

Table 5 shows the results of the emulsion stability of the proteins A and C, when the dispersion was made at different temperatures. That the temperature of dispersion has an influence on the emulsion stability is quite clear, although the influence is not equal in both type of proteins.

If the theory is accepted that the oil/water emulsion in sausages is stabilized by a protein skin around the fat globule, it is understandable that the W.S.P. plays an important role in the emulsion stability of oil/water emulsions.

At a factory using one of the isolated soy proteins, a substantial fat separation caused a sudden disruption in the manufacture of a certain type of luncheon meat. By analyses, we found a N.S.I. of the isolated soy protein of only 32% as compared with ±80% for the normal product. In the emulsification test the amount of oil separation was 89%, as compared with about 50% for the normal product.

This indicated first, that the N.S.I. (W.S.P.) is an indication for the quality of an isolated soy protein as an emulsion stabilizer, and secondly the excellent similarity between the results in the factory and the results of the emulsification test.

The test as described above gives one the possibility to evaluate in the laboratory different kinds of non-meat proteins. We are now trying to use this test in evaluating the emulsion stabilizing influence of different types of meat.

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Relative Activities of Commercially-Available Enzymes in the Hydrolysis of Fish Protein

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SUMMARY

The relative activities of more than 20 commercially available proteolytic enzymes were measured for the digestion of a washed and freeze-dried fish protein substrate. Concentration of enzyme required to effect a 60% digestion in a 24-hr period was the inverse measure of enzyme activity. Total soluble solids and insoluble solids were measured and used to calculate the degree of digestion. In this way more reproducible results were obtained than were possible from filtrate analysis alone.

Preliminary 1-hr tests at 40°C and pH 7 showed the enzyme ficin to be most active over a short hydrolysis period. The standard 24-hr tests were carried out at near optimum conditions of temperature and pH for each enzyme. Under the test conditions, Pronase exhibited greatest activity per unit weight, but in general the microbial proteases ranked low in relative activity. Pepsin, papain and pancreatin all combined good activity with moderate cost. Amino acid and α-amino nitrogen contents of hydrolysates at a level of 60% solubilization are compared.

INTRODUCTION

Several groups have investigated the production of enzymatic hydrolysates of fish protein. McBride *et al.* (1961) found that pepsin achieved higher solubilization of herring than did bromelin or Rhozyme B-6. Sen *et al.* (1962) studied the hydrolysis of fish flesh with papain and Sripathy *et al.* (1964) proposed a process for production of such a hydrolysate. In this laboratory, the production of soluble fish protein concentrates through enzymatic hydrolysis of whole fish, principally red hake (*Urophycis chuss*), have been investigated. Such soluble products offer advantages for use in soups, beverages and infant formulations provided that taste and nutritive value are satisfactory. Maximum conversion of fish protein into its soluble fractions consistent with economy and the nutritive and organoleptic quality of the final product is the desired end.

Miyada *et al.* (1956) compared nine proteolytic enzyme preparations for their action on rehydrated freeze-dried beef muscle. Soluble products were removed by NaOH extractions and fractionated into collagen, elastin, soluble protein and non-protein nitrogen fractions. They found that papain, bromelin, ficin, trypsin and Rhozyme P-11 all had the necessary proteolytic activity for use in meat tenderizers. We desired a simpler procedure for determination of the degree of digestion of fish protein by each of a larger number of enzyme preparations.

The manufacturers of commercially available enzyme preparations use a variety of activity assay procedures, many of which have been described by Davis *et al.* (1955). Most of them involve digestion of hemoglobin, casein or gelatin for a short time (e.g., 10 min), and the rate of hydrolysis is determined by measuring hydrolytic products. Common methods of measurement involve colorimetric determinations of color reactions between reagents and specific amino acids, measurements of ultraviolet absorption, or formol titrations; consequently, a direct comparison of the different types of activity units reported is not possible. Furthermore, since the proteolytic activity of an enzyme is dependent on the nature of the protein acted upon, reports of activity on hemoglobin, casein or gelatin substrates are not directly applicable to a fish protein substrate.

This paper describes the preparation and use of a washed and freeze-dried fish protein substrate to determine the relative activities of more than 20 different commercially-available enzymes. Both dissolved and undissolved solids are measured to obtain more reproducible results than are possible from analysis of the filtrate alone. Relative activities are based on degree of digestion of fish protein after 24 hr.

MATERIALS AND METHODS

Substrate. A standard fish protein substrate powder for use in enzyme assays was prepared from haddock

"sawdust" supplied by Gorton's of Gloucester. The sawdust is waste material from the process of sawing frozen blocks of haddock fillets into fish sticks and portions.

Twenty pounds of the sawdust were partially thawed and passed through a Hobart Mill. The comminuted sawdust was slurried with an equal weight of distilled water and cooked at 103°C for 50 min. The cooked slurry was filtered and the filter cake was extracted with 40 lbs of distilled water for 1 hr. The wash water was removed by centrifugal filtration, and the filter cake solids were freeze-dried and then extracted with diethyl ether, batchwise, for 1.5 hr in a Soxhlet extractor. The final analysis obtained for the fish protein powder was 94.62% crude protein ($N \times 6.25$), 3.44% moisture, 1.68% ash and 0.48% fat.

Enzymes. All types of proteolytic enzymes tested are commercially available in bulk quantities. The following companies supplied free samples of enzymes as indicated:

Cudahy Laboratories, Omaha, Nebraska: Pepsin (1:10,000) and Pancreatin (3 × N.F.).

Enzyme Development Corporation, 64 Wall Street, New York, New York: Ficin, Panol, and Bacterial Proteinase NOVO.

Miles Laboratories, Elkhart, Indiana: Ficin, Papain, HT Proteolytic, Bromeliq, Bromelin (1:10) and Fungal Protease.

Rohm and Haas, Special Products Department, Philadelphia, Pa.: Rhozyme P-11 and Rhozyme PF concentrate (58.92 ×).

Wallerstein Company, Staten Island, New York: Papain and Prolase.

Wilson Laboratories, Chicago, Illinois: Pepsin (1:3,000) and Trypsin (1:80).

Also tested were Pronase, sold by Cal BioChem, Los Angeles, California, and Bromelin, Ficin, Papain, Pepsin (1:10,000), and Trypsin (4 × U.S.P. Pancreatin) sold by Nutritional Biochemicals Corporation, Cleveland, Ohio.

Standard assay procedure. The assay procedure was designed to determine the concentration of each enzyme required to solubilize 60% of the initially insoluble fish solids in a 24-hr hydrolysis period. Each enzyme was tested at pH 6.0, 7.0 or 7.5 (except pepsin, tested at pH 2). The particular pH used was that value nearest the optimum pH or the median pH within an optimum range as listed by the enzyme manufacturer. The test temperature was also set near the optimum as indicated by the supplier of each enzyme.

The procedure was:

1. One gram of fish protein powder and 18 ml of 0.2*M* phosphate buffer containing 0.7% sodium benzoate as a bacteriostat were added to each of a series of wide-mouth sample bottles.
2. The slurries were cooked for 30 min at 5 psig steam pressure and then cooled to the test temperature.
3. Freshly prepared enzyme solution was added at the desired concentration to each sample bottle at intervals. Total sample volume was brought to 20 ml with distilled water and incubation was started.
4. Samples were shaken periodically during the 24-hr incubation and the net weight of slurry contained in each was determined.
5. At the end of 24 hr each sample was filtered immediately through a previously tared and marked sheet of Whatman #4 filter paper.
6. The filtrate was weighed and dried for determination of the percent dissolved solids.
7. All solid particles were flushed from the sample bottle onto the tared filter paper and the filter cake was washed with 100 ml of distilled water. Nine-cm filter sheets were held in a Seitz L-6 vacuum filter (4.8 cm I.D.) for retention of all insoluble solids as a cake in the center of the paper.
8. The washed solids and filtrate samples were dried overnight at 95°C for determination of insoluble and dissolved solids.
9. Enzyme activities were calculated as follows:
   a. Total insoluble solids (I.S.) were determined from dry weight of the washed filter cake.
   b. Percent dissolved solids (% d.s.) in the filtrate was determined from the dried filtrate sample.
   c. The net dry weight of soluble fish solids (D.S.) was calculated as follows:

$$\text{D.S.} = (\%\ \text{d.s.})(\text{W}_\text{S} - \text{I.C.})/100 - \text{W}_\text{E} - \text{W}_\text{B} \qquad [1]$$

Where: W_S = total weight of the slurry, g.
W_E = weight of soluble enzyme added, g.
W_B = weight of buffer salts contained, g.

   d. A digestion ratio, DR, equal to the ratio of solids solubilized to solids remaining insoluble was calculated:

$$\text{DR} = \frac{(\text{D.S.}) - (\text{D.S.})_\circ}{\text{I.S.}} \qquad [2]$$

Where: $(\text{D.S.})_\circ$ = weight of fish solids soluble initially as determined from control sample.

   e. A plot of DR versus enzyme concentration on logarithmic graph paper was linear or very nearly linear for all enzymes studied. In addition, spacing between individual activity lines was greater than for a similar plot of percent insolubles solubilized. This facilitated determination of the concentration of each enzyme at DR = 1.5, which corresponds to the solubilization of 60% of the initially insoluble protein. The activity-concentration curves for most enzymes were based on duplicate samples at each of three enzyme concentrations.

One-hour assay. In an initial series of tests the relative activities of the proteolytic enzymes were measured during a 1-hr hydrolysis at 40°C and neutral pH. The enzymes were compared at DR = 0.5, which corresponds to digestion of one-third of the initially insoluble solids.

Additional analyses. Triplicate samples with each type of enzyme were hydrolyzed 24 hr at enzyme concentrations sufficient to make soluble approximately 60% of the total fish solids. The sample filtrates were analyzed for total nitrogen according to Section 2.042 of the AOAC Official Methods (AOAC, 1965). Alpha-amino nitrogen was estimated by formol titration. One ml of sample filtrate with phenolphthalein indicator was adjusted to about pH 8. One ml of neutralized formaldehyde solution was then added and the sample was again titrated to the first permanent pink color with 0.02*N* NaOH. $(\text{Meq. NaOH}) \times (14 \frac{\text{MgN}}{\text{Meq}})$ = mg α-amino N per ml. Filtrate samples were acid hydrolysed prior to determination of amino acids on an analyzer as described by Spackman *et al.* (1958).

RESULTS AND DISCUSSION

One-hour assay. Results of the 1-hr

hydrolysis tests are given in Table 1. They illustrate the rapid action of the enzyme ficin and its suitability for short term hydrolyses.

These preliminary tests could have been improved by adjustment of test temperatures to near optimum for each enzyme. Ficin would remain most active but the relative ranking of the papains would be much higher. Hydrolysis at neutral pH (except pepsin at pH 2) seems to be justified because it simplifies the procedure and most enzymes are near optimum activity at pH 7. To estimate the degree of digestion attainable at near optimum conditions of temperature and pH, a 24-hr hydrolysis procedure was chosen as the basis for relative activity rankings.

Twenty-four-hour hydrolyses. The graphical method of activity estimation is illustrated by Fig. 1. This is a logarithmic plot of the digestion ratio, DR, versus concentration for a number of the enzymes tested. Points of intersection with the 60% digestion line (DR = 1.5) indicate individual enzyme concentrations of equivalent activity. Since these activity lines are almost parallel to each other the enzymes could have been compared at 50% or 70% digestion without a change in the relative positions on an activity scale.

Table 2 lists 20 proteolytic enzyme preparations along with test conditions used and relative activities measured for the 24-hr digestions. Several types of enzymes are more active than ficin over the extended hydrolysis period. The most active is Pronase, a fungal protease of *Streptomyces griseus.* It is a byproduct of Streptomycin production but at present its usefulness is limited by a very high market price.

On the basis of lowest cost per unit of proteolytic activity the most suitable enzymes are pancreatin, pepsin and panol (papain). Pepsin at pH 2 and papain at high temperature can be used with little chance of bacterial contamination. In general the proteolytic activities of the microbial proteases were disappointing but Bacterial Proteinase Novo and Rhozyme PF concentrate showed the most promise after Pronase for the digestion of fish protein. Ficin is most suitable for a short hydrolysis period of a few hours. The other enzymes of lower apparent activity are not to be overlooked. Factors of enzyme cost, effectiveness in conjunction with the native enzymes of whole fish and final product characteristics are all important in determining the true potential of an enzyme for production of soluble fish protein concentrate.

The results of formol titrations of the hydrolysates at approximately 60% solubilization of total solids are presented in Table 3. Average chain lengths of three to four amino acid residues per protein fraction are indi-

Table 1. Relative activities of proteolytic enzymes from 1-hr hydrolysis at 40°C and neutral pH.

Enzyme	Manufacturer	Enzyme concentration at ⅓ digestion of insolubles (DR = 0.5) Wegiht %	Relative activity[2] g/g
Ficin	Miles Chemical Co.	0.111	900
Ficin	Enzyme Development Corp.	0.212	470
Ficin	Nutritional Biochem. Co.	0.285	350
Pronase	Cal Bio Chem	0.290	345
Pepsin[1] (1:10,000)	NBC	0.385	260
Rhozyme P.F. Conc.	Rohm and Haas	0.53	189
Bromelin	NBC	0.86	116
Papain	Miles	1.12	89.3
Bact. Proteinase	EDC	1.23	81
Trypsin (4 × USP)	NBC	1.45	69
Panol	EDC	1.50	67
HT Proteolytic	Miles	1.50	67
Papain	Penick	3.0	33.3
Bromeliq	Miles	4.25	23.6
Papain	NBC	6.1	16.4
Rhozyme P-11	Rohm and Haas	11.0	9.1

[1] Pepsin digestions carried out at pH 2. Activity of pepsin is 1:10,000 based on coagulated egg albumen.
[2] Relative activity is equivalent to the weight ratio (g substrate/g enzyme) at which one-third of the substrate is digested in 1 hr.

Table 2. Relative activities of proteolytic enzymes from 24 hr hydrolysis at near optimum pH and temperature.

Enzyme	Mfgrs. specified optimum range		Test		Enzyme conc. at DR = 1.5 Weight %	Relative[1] activity g/g
	pH	Temp. °C	pH	Temp. °C		
Pronase (Cal Biochem)	7–8	50	7.5	50	0.09	1110
Pepsin (Cudahy 1:10,000)	2	40–50	2	50	0.10	1000
Pepsin (NBC 1:10,000)	2	40–50	2	50	0.13	770
Papain (Miles)	6–8	60–70	7	65	0.27	370
Panol (EDC)	5–7	50–70	6	65	0.34	294
Papain (Wallerstein)	5–6	60–70	6	65	0.34	294
Pepsin (Wilson 1:3,000)	2	40–50	2	50	0.35	286
Trypsin (Wilson 1:80)	7–9	40	7.5	40	0.45	222
Pancreatin (Cudahy)	7–9	40	7.5	40	0.45	222
Ficin (Miles)	5–8	30–50	6	40	0.50	200
Ficin (EDC)	4–9	30–50	6	40	0.60	167
Trypsin (NBC 1:80)	7–9	40	7.5	40	0.69	145
Rhozyme PF (Rohm & Haas) Concentrate (58.92×)	5–8.5	40–60	7	50	0.91	110
Bromelin (NBC)	4–9	30–60	6	50	1.00	100
Bact. Prot. (EDC)	7	–	7	50	1.28	78
HT Prot. (Miles)	6–9	50	7.5	50	3.1	32.3
Rhozyme P-11 (Rohm & Haas)	6–9	40–50	7.5	50	5.3	18.9
Prolase (Wallerstein)	3–8	40	6	40	>10	<10
Bromelin (Miles 1:10)	4–9	30–60	6	50	>10	<10
Fungal Protease (Miles)	4–7.5	30–50	6	40	>10	<10

[1] Relative activity is equivalent to the weight ratio (g substrate/g enzyme) at which 60% of the substrate is digested in 24 hr.

Table 3. Percent α-amino nitrogen from data of formol titrations and Kjeldahl analyses; fish protein approximately 60% solubilized.

Enzyme	pH	Solubles Weight % total solids	Total nitrogen mg/ml	α-amino nitrogen mg/ml	% α-amino nitrogen
Control	6	7.5	0.680	0.158	23.2
Control	7	16.9	1.42	0.361	25.4
Control	7.5	17.5	1.64	0.354	21.6
Bromelin	6	57.5	5.63	1.27	22.6
Bact. Proteinase	7	62.0	5.07	1.464	28.9
HT Proteolytic	7.5	59.5	4.92	1.272	25.8
Papain (Miles)	7	59.3	4.32	1.07	24.8
Ficin (Miles)	6	59.0	4.97	1.17	23.6
Trypsin (NBC)	7.5	61.0	5.20	1.40	26.8
Pronase	7.5	60.7	5.07	1.36	26.6

Table 4. Essential amino acid balance, 24-hr test hydrolysates; approximately 60% of total solid soluble.[1]

Enzyme	Temp. °C	pH	Solubles weight % total solids	Lysine	Threonine	Valine	Methionine	Isoleucine	Leucine	Phenyl-alanine
				Essential amino acids as percent of total amino acids [1]						
Pepsin (NBC)	50	2	62.2	10.46	4.56	5.35	3.44	4.56	8.51	3.56
Bromelin (NBC)	50	6	57.6	10.65	4.50	4.97	3.06	4.31	8.46	3.01
Ficin (Miles)	40	6	59.0	10.01	4.60	5.02	3.44	4.38	8.70	3.40
Bact. Prot. Novo	50	7	62.0	10.02	4.56	5.05	3.34	4.49	8.53	3.51
Papain (Miles)	65	7	59.3	9.86	4.58	5.29	3.23	4.34	8.39	3.36
Trypsin (NBC)	40	7.5	61.0	9.20	4.93	4.76	2.81	4.06	7.65	3.02
Pronase	50	7.5	60.7	10.07	4.49	5.07	3.34	4.52	8.56	3.56
HT Proteolytic	50	7.5	59.5	10.03	4.37	5.13	3.32	4.55	8.52	3.39
Fish protein substrate	—	—	—	9.98	4.33	5.62	3.48	5.14	8.67	4.22

[1] Tryptophan analyses not available.

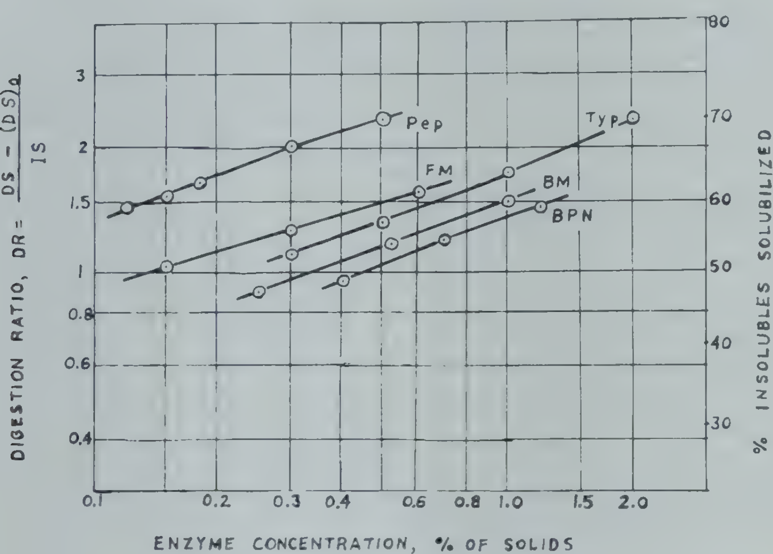

Fig. 1. Digestion ratio versus enzyme concentration: Pep = Pepsin (NB); FM = Ficin (Miles); Typ = Trypsin (NBC); BM = Bromelin (NBC); BPN-Bacterial proteinase Novo (EDC).

cated. A correlation between average chain length and such product characteristics as bitterness and hygroscopicity is anticipated and will be the subject of a future investigation.

Amino acid analyses were performed on a number of hydrolysates at approximately equal solubilization of total solids. Although the precision of the individual amino acid analyses is within ± 5%, the total amino acid recoveries as a percentage of crude protein varied greatly among the different hydrolysates. Amounts of individual amino acids are expressed in terms of percentage of total amino acids (Table 4) to indicate the balance of essential amino acids in each hydrolysate. Compared to the fish protein substrate the hydrolysates are lower in isoleucine and phenylalanine. The trypsin hydrolysate is lower in several essential amino acids. These preliminary results are subject to further investigation, however.

The use of a 24-hr digestion period to determine relative activities gives an indication of the economic usefulness of each enzyme for the digestion of fish protein. More commonly used assay procedures measure only the initial rate of hydrolysis and do not indicate the degree of digestion attainable. Ficin obviously hydrolyses fish protein at a rapid initial rate but the degree of digestion obtained is limited.

Measurements of both dissolved and insoluble solids gave more reproducible results than were possible from filtrate analyses alone. Digests of whole fish cannot be analyzed in the same manner, however, because attempts to wash the undigested solids on the filter paper result in rapid clogging of the filter. Systems containing whole, unsterilized fish must be studied, however, because the action of the native enzymes of the whole fish is an important factor in the development of an economical process for a protein hydrolysate. Therefore the relative activities determined on a washed, heat inactivated fish protein substrate are being used to select enzymes for further studies with whole fish digestions.

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The use of manufacturers' and trade names throughout this article is for informational purposes only and does not necessarily imply endorsement.

END OF RESEARCH SECTION

BREEDING GROUNDS for New Products & Processes

NEW FOOD PATENTS

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Meat & Fish Products

Hog Carcass Singeing—U.S. 3,397,423 (P. Burch; Wolverine World Wide) The body portions are singed by alternately oscillating, vertically traveling burners on support carriages, and the head and neck portions are singed by carriage mounted head burner means which are elevated when a detector engages a hog snout.

Sausage Products—U.S. 3,399,065 (H. Wistreich, H. Gorsica, D. Peryam; B. Heller & Co.) Powdered milk and dry enzymes capable of precipitating proteins are incorporated into wet macerated meat mixtures to enhance moisture retention properties.

Fish Treating Apparatus—U.S. 3,399,422 (E. Hartl, A. Dudszus, R. Franz, C. Rethfeldt, G. Wienert, R. Muke, F. Hauptmann, G. Bolze; Institut für Schiffbau) Apparatus for cutting away the head and stomach of fish and for filleting the fish while removing the spine and ribs.

Collagen Fiber Coated Sausages—U.S. 3,399,423 (E. Kielsmeier, W. Paynter; Oscar Mayer) Extrusion apparatus having a separate coating delivery passage through which material is delivered for deposit onto the surface of the emulsion while the product is being extruded into a casing.

Sausage Casing Closure—U.S. 3,401,042 (E. Frederick, L. Meredith; Tee-Pak, Inc.) Clear cellulosic sausage casings are pleated at one end and riveted to string or polypropylene casing hangers.

Sterilization Process—U.S. 3,401,044 (D. Corlett, A. Anderson, P. Elliker, K. Krabbenhoft; Battelle Development Corp.) Bacteria in meat are rendered sensitive to ionizing radiation by the incorporation of chloride ion along with sodium nitrite or sodium nitrate.

Pork Rind Product—U.S. 3,401,045 (P. Halpern; Parker Products, Inc.) Aggregates of small pieces of green pork rind are rendered in a fatty cooking liquid and cured in a liquid flavoring medium. After drying, the pieces can be popped in a heated liquid medium.

Meat Curing Composition—U.S. 3,401,046 (J. Mahon; Calgon Corp.) Made by hydrating a hydratable phosphate with a solution of sodium nitrite or nitrate containing no more water than sufficient to fully hydrate the phosphate.

Fish Processing—Br. 1,121,626 (Nordischer Maschienenbau Rud. Baader) Fish are moved beneath a pair of vertically reciprocating transverse cutters after which a circular cutter opens the belly longitudinally and a gripper removes the bridge, gills and entrails.

Sausage Casings—Br. 1,122,504 (Tee-Pak Inc.) Slurry of limed animal hide collagen is extruded into a coagulating bath of sodium sulfate to form a thin walled collagen tube, which is tanned, washed, plasticized, dried and shirred.

Sausage Casings—Br. 1,122,505 (Tee-Pak Inc.) Collagen casings are tanned by contact with aqueous solutions of edible non-toxic dialdehydes such as glutaraldehyde.

Meat Emulsification—Br. 1,122,522 (Oscar Mayer & Co. Inc.) Apparatus employing centrifugal cutters.

Coating of Sausage Casings—Br. 1,124,180 (Tee-Pak Inc.) Internal coating with flavoring, coloring, release, or stabilizing agents by mechanically shirring the casing on a hollow mandrel through which a gas-borne coating is injected.

Meat-curing Compositions—Br. 1,124,605 (Albright & Wilson Mfg. Ltd.) Free flowing meat curing compositions having a reduced nitrite toxicity hazard are prepared by mixing hydratable alkali metal phosphates with alkali metal nitrates or nitrites in a limited amount of water, not more than 120% of that required for complete hydration of the phosphate.

Meat Extrusion—Can. 794,301 (E. Rongey, R. Hlavacek; Swift & Co.) Comminuted meat emulsions are passed through a conductively heated forming device of rigid plastic to set the meat product to a self-sustaining form.

Meat Tenderizing—Can. 794,302 (J. Greenspan; Frigidmeats, Inc.) Tenderizing liquid is applied to pieces of meat by sliding the pieces across a tilted table while subjecting them to the action of the plurality of reciprocating, meat penetrating rods bathed in meat tenderizing liquid.

Sausage Making Apparatus—Ger. 1,266,661 (Oscar Mayer Kartridg Pak S.A.) Apparatus for comminuting, deaerating, and extruding meat compositions into casings.

Sausage Casing Additive—Jap. 15773/68 (Kureha Chem. Ind. Co. Ltd.) Synthetic casings are coated internally with ortho or polyphosphate compositions to enhance adherence of the casing.

Dairy Products

Cheese Processing—U.S. 3,401,041 (W. Nelson) Packaging and shaping apparatus and a method for receiving, packaging, pressing and shaping curd used in the manufacture of cheese.

Milk Preservation—Br. 1,123,647 (Nestlés Products Ltd.) Lactic protein-containing milk or cream products are preserved by the addition of rennet, neuraminidase, pyrophosphates or coagulants.

Sour Cream Product—Br. 1,124,238 (National Dairy Products Corp.) Commercial sour cream compositions are prepared by combining sour cream with 0.15–0.5% low methoxyl pectin, 0.20–0.40% gelatin, heating at 155–185°F, acidifying and homogenizing.

Frozen Powdered Cream—Ger. 1,274,860 (Alpusa GmbH Lebens- & Genussmittel) Thin layers of frozen cream are scraped from a freezing drum and packaged at −18 to −20°C.

Cereal Products & Baked Goods

Tortilla Forming Apparatus—U.S. 3,397,655 (H. Valadez, R. Perez) Machine provided with first and second hot plate members between which a lump or ball of dough may be flattened and at least partially surface cooked.

Flour Production—U.S. 3,399,838 (W. Hanser; National Oats Co.) Whole fiber covered kernels of grain are reduced to flour with a minimum of ruptured cells by chilling the kernels to about −50 to −225°F, and grinding the kernels and fibers to flour fineness.

Corn Milling—U.S. 3,399,839 (H. Anderson, D. Trommer; Quaker Oats Co.) The moisture content of the corn is adjusted to 19–23% by weight after which it is subjected to the abrading action of a wire brush to remove bran.

Quick Cooking Rice—Br. 1,121,893 (Irish Sugar Co. Ltd.) Raw polished rice is heated in water to a moisture content of 25–35% after which a chelating agent and a starch-

complexing agent are added to the water and the rice is simmered to increase its moisture content to 65%. The rice is steamed to complete gelatinization after which it is washed and dried.

Toaster-Heatable Baked Products—Br. 1,124,150 (General Foods Corp.) Dough crust food products containing a fruit filling and having a shelf life of at least six months.

Dry Gluten Products—Can. 793,779 (B. Landfried, John Moneymaker; Top-Scor Products, Inc.) Vital wheat gluten particles are rendered stable against particle cohesion in neutral aqueous dispersion by coating them with nonionic hydrophilic lipids such as monoglycerides, salts of lactylic esters of fatty acids, polyoxyethylene stearate or stearoyl monoglyceridyl citrate.

Ready-To-Eat Oat Cereal—Can. 794,791 (E. Lilly, R. Reinhart; Quaker Oats Co.) Cooked oat groats are kneaded at 150–212°F to form a cooked oat dough which is formed into flakes and flash dried by air contact at 400–800°F.

Coated Rice Product—Can. 794,792 (R. Nibler, A. Roseman; National Dairy Products Corp.) Water is added to rice to form a moistened surface of gelatinized rice on dry rice grains, after which they are mixed with a coating material and dried.

Instant Rice Product—Ger. 1,273,968 (Ataullah Khan Ozai-Durrani) Rice grains are heated in water at 65°C to increase their moisture content to 30%, are heated in water to 100°C to increase the moisture content to 60–75% and are finally dried to reduce the final moisture content to 10–14%.

Oilseed Products

Olive Processing—U.S. 3,397,999 (R. Kellerman; V.R.Smith Olive Co., Inc.) Olives are preserved prior to canning by placing them in an aqueous, brine-free solution containing about 0.1%–0.3% by weight of phosphoric acid.

Soy-Base Milk—U.S. 3,399,997 (G. Okumura, J. Wilkinson) Slurry of sprouted soybeans is extracted to yield a suspension of fine solids. The solids are precipitated to form a curd which is comminuted, suspended in fresh water and mixed with additives to simulate natural milk.

Peanut Cleaning Apparatus—U.S. 3,400,814 (O.Hobbs) Vibrating conveyor for removing dense articles such as stones from peanuts.

Nut Processing—U.S. 3,401,730 (B. Mathews, P. Frentzen) Mixtures of nuts of non-uniform size are conveyed to a first station where the larger of the nuts are subjected to shear and compressive forces by engagement between resilient surfaces moving in the same direction but at different velocities. The remaining nuts are conveyed to a second station where they are subjected to similar shear and compressive forces.

Oil Mill Residue Recovery—U.S. 3,402,165 (H. Krefeld; Protein-Compagnie GmbH) Process for treating oilseed mill residues to obtain a protein fraction, a soluble component fraction and a fraction of fiber material.

Oils & Oil-Based Foodstuffs

Imitation Cream Cheese Spread—U.S. 3,397,994 (G. Elebogen, M. Baron; Vitamins, Inc.) Dietary spreads resembling cream cheese and containing from 15 to 40% highly polyunsaturated fat, 5–13% phosphoprotein solids and water.

Imitation Cream Cheese Composition—U.S. 3,397,995 (G. Elebogen; Vitamins, Inc.) Emulsified edible spreads resembling cream cheese are produced by homogenously mixing 15–40% by weight fat, 0.1–2% of a stabilizing vegetable gum, 5–13% of phosphoprotein solids, 0.2–3% lactic acid, the balance being water, and then recovering therefrom a solidified spread product.

Glyceride Shortenings—U.S. 3,397,996 (R. Darragh, K. Nelson; Procter & Gamble) Shortening compositions suitable for the preparation of cakes and icings and containing mixtures of monoglycerides, polyoxyethylene sorbitan monoesters, decaglycerol esters, and half esters of dicarboxylic acids with monoesters of straight chain aliphatic diol.

Oleaginous Gel Compositions—U.S. 3,397,997 (C. Japikse; Procter & Gamble) Oleaginous gel compositions having a stable beta crystalline phase are prepared by rapidly chilling to less than 85°F in less than 60 seconds a completely melted mixture containing 92–99% of a liquid glyceride oil having an iodine value of 107 or greater, and from 1–8% of a solid triglyceride having an iodine value of less than 12, the solid triglyceride consisting of a blend of beta-phase-tending hardstock and non-beta-phase-tending hardstock.

Pourable Refrigerated Margarine—U.S. 3,397,998 (W. Fricks; Fricks Foods, Inc.) Conventional margarine refrigerated to solid condition at about 40°F is mixed with an equal quantity of edible vegetable oil which remains liquid at about 40°F and subjected to violent stirring action to yield a margarine product which is pourable at that temperature.

All-Purpose Shortening—U.S. 3,402,050 (N. Howard, J. Martin; Procter & Gamble) All-purpose plastic shortening compositions comprising fatty glycerides having mixed therein 0.5–10 parts per million of methyl silicone and 0.25–4% of a material selected from the group consisting of a) condensation products of dicarboxylic acids and fatty acid monoesters of straight chain aliphatic diols containing from 3 to 5 carbon atoms, b) condensation products of dicarboxylic acids and partial fatty acid glycerides containing an average of from 1–2 fatty acid radicals, and c) acid anhydrides of said condensation products.

Margarine Composition—Br. 1,121,662 (Unilever) Improved melting and spreading properties are provided by use of oil mixtures containing at least 80% sunflower derived oils in which 60–90% of the fats, including at least 75% of the sunflower oil, are randomly esterified.

Margarine Compositions—Br. 1,124,-

084 (Procter & Gamble) Compositions based upon oleaginous gels of the type described in U.S. 3,397,997 above.

Powdered Fat Composition—Br. 1,124,734 (J. Bibby & Sons Ltd.) Mixtures of fat particles having a melting point of not less than 30°C, sweetening agents, proteins, glyceryl monostearate, and lecithin are homogenized and spray dried to yield compositions useful in preparing whippable mixtures with water or milk.

Edible Emulsion—Can. 793,250 (H. Pinkalla, G. Neuser, L. Cook, R. Korfhage; W. R. Grace Co.) Edible water-in-oil emulsions containing up to 10% of edible waxes and employing mixtures of hydrophilic and lipophilic nonionic emulsifiers.

Alkali Refining Process—Can. 793,872 (P. Seip; Unilever) Mixtures of free fatty acid esters contaminated with free fatty acid are mixed with fatty acid esters containing a lower percentage of free fatty acid in such proportion that the resulting mixtures contain a free fatty acid percentage of less than 4% after which they are neutralized by the action of aqueous alkali.

Treatment of Fats—Can. 793,873 (L. Faur, P. Westdorp; Unilever) Mixtures of liquid and crystalline fatty material are separated by forming a mixture with water and wetting agent from which the crystalline materials may be separated.

Degumming of Vegetable Oils—Can. 794,370 (A. Jakubowski, C. Mikitiuk, M. Otowski, A. Skrzypczak; Instytut Przemyslu Tluszczowego) Continuous process for degumming vegetable oils and producing lecithin from the phosphatide slimes which are obtained.

Low Fat Spreads—Can. 794,793 (E. Barker; Better Spreads, Inc.) Table compositions readily spreadable at home refrigeration temperatures have a viscosity substantially constant between 35 and 100°F comprising emulsions of butterfat particles containing 15–49% butterfat, 6–18% protein derived from nonfat milk solids and 15–30% retained moisture.

Fat Deaeration—Ger. 1,274,429 (Margarine-Union GmbH) Edible fats and oils are injected with inert gases in a process in which the oxygen content of the composition is continuously monitored by polarography.

Sugars, Starches & Confectionery

Invert Sugar Production—Br. 1,116,888 (C.F.Boehringer & Soehne GmbH) Molasses is subjected to acid hydrolysis to convert sucrose to glucose and fructose after which the hydrolysate is subjected to chromatographic separation with a cation exchange resin in salt form.

Saccharide Derivatives—Br. 1,122,965 (Penick & Ford Ltd.) Process for the production of hydroxypropylated polysaccharides which are palatable and highly resistant to digestive enzymes.

Dextrose and Maltose Products—Br. 1,124,747 (Karl Kristian Kobs Kroyer) Polysaccharide medium such as starch milk is mixed with portions of liquefying enzymes and passed through a tubular heat exchanger. Partly liquefied material is then passed through a second heat exchanger under pressure to achieve a temperature of 110°C after which it is cooled and combined with further enzyme to bring about completion of liquefaction.

Dry Fondant Compositions—Can. 793,778 (F. Harding, R. Horowitz, A. Monti; SuCrest Corp.) Free-flowing reconstitutable granular fondant compositions consisting of agglomerates of pulverized sugar containing up to 30 parts by weight of a non-crystallizable ingestible organic binding agent for each 100 parts of pulverized sugar.

Sugar Production—Jap. 16794/68 (Knapsack AG) Polyphosphoric acid or itaconic acid is added to sugar solutions obtained from sliced cane or beet, and the resulting composition treated in an ion exchange tower.

Sugar Purification—Jap. 16795/68 (Meiji Sugar Mfg. Co.) Polyphosphates are added to a crude sugar solution or molasses containing organic or inorganic impurities after which the mixture is diluted to less than 45° Be to form a gel solid at pH 4–10. Impurities are removed as a precipitate.

Shaped Powdered Sugar—Jap. 16796/68 (S. Kato) Apparatus for molding powdered sugar shapes packaged in synthetic film.

Sugar Purification—Jap. 16797/68 (Shibaura Sugar Refining Co.) Waste beet sugar is diluted with water to 9.0° Be, processed by the Steffen process, subjected to carbonation and treated with a strongly acid cation exchange resin. The solution is then decolorized by passage through a porous strongly basic anion exchange resin.

Sugar Purification—Jap. 16798/68 (Colonial Sugar Refining Co.) Calcium ions in impure sugar cane syrups are insolubilized by acidification after which the syrup is neutralized in the presence of ammonium orthophosphate. Impurities and divalent metal cations are removed with the precipitate.

Sugar Separation—Jap. 16799/68 (Toyo Seito K.K.) Mixtures of grape sugars and fruit sugars are separated by treatment with mixtures of methanol and ketones in the presence of strong mineral acids or organic acids such as benzenesulfonic acid.

Starch Taste Improvement—Jap. 16800/68 (Ajinomoto Co. Ltd.) Saccharified starch is held in solution with alpha-amylase at a pH of less than 5 and a temperature higher than 50°C to precipitate colloidal materials containing bitter taste components.

Fruit & Vegetable Products

Frozen Potato Products—U.S. 3,397,993 (W. Strong; McDonald's System) Potato segments are blanched to translucency, dehydrated internally to a weight loss of up to 35%, fried for a short time and then frozen for subsequent finish frying.

Avocado Processing—U.S. 3,398,001 (E. Benson; Air Reduction Co.) Avocados from which the seed has been removed are dipped in an antioxidant composition and partially frozen by immersion in a bath of liquid nitrous oxide or nitrogen. After the avocado is completely frozen by equilibration at a temperature of 0–28°F, its entire surface is glazed by dipping it again in the antioxidant. The frozen avocado is then packaged in a container having a nitrogen atmosphere with an oxygen content of less than 2%.

French Fried Vegetable Products—U.S. 3,399,062 (M. Willard, G. Roberts; Rogers Bros. Co.) Aggregates of dehydrated starch-containing vegetable material are mixed with thermal gelling cellulose ether binders, rehydrated, extruded at a temperature at less than 110°F and deep fat fried.

Ketchup Manufacture—U.S. 3,399,064 (A. Partyka, G. Bosy; National Dairy Products) Ketchup is prepared by forming a mixture of ketchup ingredients without heating and then heating the mixture by contacting it with increments of steam.

Deaeration of Sliced Products—U.S. 3,399,999 (A. Ellett; Ellett Copper & Brass Co.) Mixture of fruit or vegetable slices with water is introduced to a deaerating vessel maintained under partial vacuum where the water is drained from the mixture. The drained slices are maintained in the evacuating vessel until air within the pores reduces in pressure, after which the slices are discharged through a column of water.

Vegetable Trimming Apparatus—U.S. 3,400,740 (Y. Akesson; Produits Findus S.A.) Apparatus for trimming brussels sprouts, having movable cutters and a channel parallel to the path of the cutters and which is adapted to impart to the vegetables a rolling over and translational movement along the channel.

Grape Processing—U.S. 3,401,040 (M. Nury) Crushed grapes are allowed to separate by gravity into a lighter pulp solids layer and a heavier liquid layer. After natural enzymes are allowed to condition the grapes, additional grapes are introduced into the settling zone while solids are withdrawn from the top surface of the zone and liquid is drawn from the bottom of the zone.

Cherry Processing—U.S. 3,401,726 (K. Allen, C. Harper) Rotating drum apparatus for removing stems from cherries.

Low Fat Potato Chips—U.S. 3,402,049 (J. Mancuso, A. Capossela; General Foods) Raw potato slices are soaked in an edible fat, drained, subjected to an elevated temperature to surface-fry and dehydrate them to yield a chip product having a total fat content of 20–30%.

Potato Product—Can. 793,252 (B. Hilton; Frito-Lay, Inc.) The viscosity of mixtures of finely divided raw potato solids and liquid is increased by heating the mixture to gelatinize at least 80% by weight of the starch after which it is formed into shaped bodies and cooked.

Beans Processing—Can. 794,149 (B. Weirauch; Maschinenfabrik August Herbort KC) Rotating destemming apparatus for removing stems from pod vegetables or separating vegetable pods having a branched connection.

Onion Processing—Can. 794,150 (L. Parsons; Leslie A. Parsons & Sons Ltd.) Skins and other inedible layers of onions are removed by sub-

jecting them to a fluid stream blast.

Fruit Slicing Apparatus—Can. 794,-151 (W. Pease, L. Page; F. B. Pease Co.) Appraatus for slicing cored fruit or the like into rings employing pin means for orienting the fruit along its core axis and means for slicing the fruit transversely of its core axis.

Coffee, Tea & Cocoa

Freeze-Dried Coffee—U.S. 3,399,061 (G. Lutz; General Foods) Freeze drying process for producing coffee of dark coffee-like color having a Munsell color rating of between 12.5, 2.5/4 and 17.5, 5/6.

Coffee Roasting—U.S. 399,998 (W. Morrison; Union Stock Yard and Transit Co.) Green coffee beans are roasted in a sealed container at 400–700°F after which the pressurized contents are discharged into a low pressure, sealed recovery container with resulting popping of the roasted beans. The recovery container is maintained at a temperature below 100°F to condense released vapors. The contents of the container are churned to bring the popped porous beans into contact with the condensate before removal and packaging.

Coffee Bean Roasting—Br. 1,122,894 (General Foods) Green coffee beans are quenched and tempered to raise their moisture content prior to roasting to provide a final product having less undesirable volatiles and carbon dioxide.

Soft Drinks & Fruit Drinks

Powdered Beverage Mixes—Can. 794,-300 (R. Gidlow, W. Ganske, F. McCarron, J. Stein; The Pillsbury Co.) Dry mixtures of citric acid and synthetic sweeteners are wetted to increase their moisture content by not more than 3.5% after which the wetted particles are randomly contacted to form porous agglomerates.

Frozen Beverage Concentrate—Br. 1,-124,335 (General Foods) Pulp flotation agents such as water soluble or water swellable gums are added to beverage concentrates containing fruit pulp dispersed in ice to support and maintain the pulp in suspension when the concentrate is diluted.

Beer & Brewing Materials

Continuous Lagering Process—U.S. 3,399,996 (D. McKay; Phillips Petroleum Co.) Continuous lagering process conducted at a pressure of 100–30,000 psig in which a portion of the lagered beverage is recycled while the remainder is chilled to produce a slurry of ice crystals and concentrated beverage which are separated.

Vollbier Type Beer—U.S. 3,402,048 (T. Hank; Bierbrauerei Becker OHG) A first portion of wort is boiled with an amount of hops and acidified malt as required for the final product and fermented. A second portion of wort is boiled without the addition of hops or malt and treated with an adsorbent. Both wort portions are then mixed and subjected to a final fermentation.

Biological Stabilization—Br. 1,23,895 (Des Produits Purs De Courcelles En Abrege "Sopura") Incorporation of esters of gallic acid with alcohols having 8 to 10 carbon atoms.

Regeneration of Nylon Stabilizer—Can. 793,284 (D. Murray, R. Quittenton; John Labatt Ltd.) Nylon which has been used to stabilize beer is regenerated by contacting it with a dilute hypochlorite bleach solution.

Foam Stabilization—Can. 793,285 (H. Peyser, J. Houston, J. Kinnavy; Continental Can Co.) Malt beverage foam is improved by adding after fermentation a small amount of a non-toxic fluorinated lower alkyl hydrocarbon containing at least one fluorine atom such as octafluorocyclobutane.

Wort Production—Can. 793,286 (V. Bavisotto; Chas. Pfizer & Co.) Malt mash to which has been added a proteolytic enzyme is held at 40–70°C for up to 90 min, after which liquefied cereal grain is added and the batch is held at between 65 and 75°C for 30–60 min.

Continuous Fermentation Apparatus—Can. 793,287 (A. Portno; Brewing Patents Ltd.) Apparatus has an inlet for fresh liquor and an outlet for fermented liquor arranged on the axis of rotation of a rotor positioned within the fermentation vessel.

Hop Flavoring Compound—Can. 793,-357 (L. Worden, P. Todd, Jr.; Kalamazoo Spice Extraction Co.) Process for the preparation of hexahydroisohumulone by the hydrogenolysis of lupulone.

Wort Preparation Apparatus—Can. 794,821 (C. Lenz) A tank, a crushing mill arranged above the tank and feeding means for feeding water and malt to the crushing mill.

Beverage Clarification—Ger. 1,272,861 (A.B. Pripp & Lyckholm) Polyvinylpyrrolidone or its tannin-albumen complexes are used in the clarification of beer, fruit juices and wines.

Continuous Malting Plant—Ger. 1,-274,548 (Y. Cauwe) Malting apparatus employing a perforated grain conveyor moving through a circular tunnel in which are stations for maceration, germination, drying, emptying and charging.

Flavors & Colors

Popcorn-Like Flavor—U.S. 3,402,041 (E. Roberts; R. J. Reynolds Tobacco Co.) Popcorn-like flavor is imparted to foodstuffs by the incorporation of pyrazine derivatives.

Glutamic Acid Production—U.S. 3,-402,104 (J. Gore, H. Reisman, C. Gardner; Merck & Co.) Continuous fermentation process by growing biotin-requiring microorganisms in a nutrient growth medium under steady-state conditions in which growth culture medium is constantly transferred to another vessel which contains a growth-limiting factor such as penicillin. Nutrient is added in amounts to create an equilibrium state where L-glutamic acid is produced in high yield at a constant rate.

Glutamic Acid Production—Ger. 1,-274,058 (Ajinomoto K.K.) Culture of a suitable microorganism in a

sugar cane or beet molasses medium containing a surfactant such as glyceryl monostearate to improve yield.

Food Additives

Thickening Agent—Ger. 1,272,887 (Kelco Co.) Mixtures of hydrophilic xanthomones colloids and locust bean gum are employed as thickeners in aqueous media.

Miscellaneous Products

Edible Snack Product—U.S. Des. 212,-070 (B. Hreschak; National Biscuit Co.)

Blended Protein Product—U.S. 3,397,-991 (R. Johnson, P. Anderson) Protein from more than one vegetable protein source is colloidally solubilized to provide a homogeneous blend of protein having a preselected assay of essential amino acids.

Milk Substitute—U.S. 3,397,992 (P. Noznick, C. Tatter; Beatrice Foods Co.) A lactalbumin and lactoglobulin free composition suitable for use as a milk substitute comprising fat, a polyglycerol partial higher fatty acid ester and colloidal cellulose dispersed in water.

Tamarind Extract—U.S. 3,399,189 (A. Gordon; National Dairy Products) Process for recovering an improved polysaccharide from tamarind seed kernels which involves sequential solvent extraction with a polar organic compound and water.

Water Desalination—U.S. 3,400,549 (G. Karnofsky; Blaw-Knox Company) Apparatus for producing potable water from saline water using a freezing or ice crystallization method including a washing step carried out in a vertical washer column.

Protein Foodstuffs—Jap. 11737/68 (Intern. Flavors and Fragrances, Inc.) Protein-containing foodstuffs are reacted with sulfur compounds such as cysteine or cystine in the absence of monosaccharides.

Equipment & Processes

Grain Drying Apparatus—U.S. 3,400,-468 (J. Matthews; National Research Development Corp.) Continuous flow grain drier having electrical moisture sensors at the input and output ends and apparatus for controlling the extent of drying in response to signals from the input and output sensors.

Aseptic Packaging—U.S. 3,401,043 (R. Dinley, J. Flanigan, E. Bowen; Pet Inc.) Flexible containers sterilized by contact with ethylene oxide are filled with sterile fluid food products and passed through a water trap containing bactericidal material. The container has a portion of the contents heat sealed from the rest of the package which can be removed for testing without contaminating the remainder.

Heating Apparatus—U.S. 3,401,626 (J. Amalfitano) Food heating apparatus having heated rotatable quartz surfaces which are adapted to engage and traverse an article of food, thereby heating said article of food to a desired degree.

Fractional Crystallization—U.S. 3,-402,047 (D. Shaul; Phillips Petroleum Co.) Crystallization separation and purification utilizing fresh feed to re-slurry crystals.

Defrosting Process and Apparatus—U.S. 3,402,053 (P. Longe, W. Root; Intern. Agri-Systems, Inc.) Method of defrosting frozen food products while in a free, partially buoyant state in a continuously moving body of heated water of a temperature insuring practical control of bacterial growth.

Fermentation Process—U.S. 3,402,103 (H. Amberg, T. Aspitarte, J. Cormack, J. Mugg; Crown Zellerbach Corp.) Conversion of carbohydrate materials to fermentation products is achieved in one pass through a vertically disposed tower containing spaced packing surfaces on which fermenting organisms are grown.

Flavoring Apparatus—Br. 1,123,517 (Lipoma Electronics Co.) Flavoring agents such as salt are added to snack foods by conveying the foodstuff through a chamber in which the air contains ionized particles of the flavoring agent.

Filling Process—Can. 793,618 (L. Benjamins) Containers are washed while introducing nitrogen gas after which the nitrogen is displaced by introducing a beverage into the container.

Preservation Process—Can. 794,298 (W. Harvey, S. Lazerus, A. Bonnet, W. Jensen; Susquehanna Corp.) Process for preserving animal and/or plant matter by retarding respiration rate through control of the content of oxygen and respiration products in the storage atmosphere.

Drying Process—Can. 794,299 (C. Husmans; Unilever Ltd.) Materials are concentrated by evaporating in droplet form a liquid which contains the material and which is attached in the form of droplets to a plurality of separated carrier filaments.

By-Product Technology & Feeds

Growth Promoters—U.S. 3,397,990 (F. Hochstein; Chas. Pfizer & Co.) Hexamethonium salts as growth promoters in animal feed compositions.

Rendering Process—U.S. 3,398,676 (H. Theobald, C. Theobald) Animal material having a particle size of one-half to two inches is heated at 140–250°F without reducing the water content by more than 40% and without reducing the fat content by more than 65% and subjected to increasing pressures to express molten fat and water and to provide a residue whose fat content is no greater than 20% by weight on an anhydrous basis.

Rendering Process—U.S. 3,398,677 (H. Theobald, C. Theobald) Rendering process similar to that described in U.S. Patent 3,398,676 above, but directed to animal materials including bones.

Animal Feed—U.S. 3,401,039 (R. Gordon, L. Machlin; Monsanto Co.) Cellulosic animal feeds containing up to 12% by weight of a linear aliphatic alcohol having 4 to 22 carbon atoms and a single hydroxyl group.

Poultry Feeds—Br. 1,122,969 (Hoffmann-La Roche & Co.) Hydrolysed paprika is added to poultry feeds to improve pigmentation properties.

Animal Feeds—Br. 1,123,884 (Chas. Pfizer & Co.) Bis-5-nitro-2-furfural carbohydrazone is employed as a growth promoter in animal feeds.

Anti-anemia Additive—Br. 1,123,965 (A.B.Ewos) Ferrous salts such as ferrous fumarate, succinate or carbonate are added to steam treated ground oat kernels or corn to reduce anemia in suckling pigs.

Metal Pellet Additives—Can. 793,251 (R. Hemingway, N. Ritchie; University of Glasgow) Pellets comprising alloys of metallic magnesium, aluminum, copper, cobalt, zinc, and nickel are fed to ruminants.

Animal Foods—Ger. 1,273,311 (General Foods Corp.) Moist, meat-containing animal foods capable of being stored without sterilization in hermetically sealed packages. The final product contains 15–30% by weight moisture and at least 15% by weight sugar. Antimycotic additives are incorporated in the food or the wrapper.

Packaging

Butter Patty Packaging—U.S. 3,398,-000 (L. Peters) Rectangular package containing a plurality of butter-pat-carrying trays which have guide rails to serve as sliding surfaces to protect the butter pats from being crushed by trays above.

Can Structure—U.S. 3,400,853 (K. Jacobsen; AB Platmanufacter) Can structures to be employed in packaging hot goods, the structures having end closures having the capability of assuming a convex or concave position depending upon differential pressure application.

Reclosable Bag Container—U.S. 3,-402,052 (R. Walker) Flexible bag type package for bread or the like having spaced apart strips of inelastic bendable material secured to opposite side walls. In closed twisted position, a substantially air-tight plug is formed by the tight intertwisting of the strips.

Plastic Laminate Packaging Material—Br. 1,117,256 (W.R.Grace & Co.) Thermoformed packages for cheese or processed meat employing a laminate of polyvinylchloride and polyethylene and optionally, a layer of polyvinylidene chloride as an oxygen barrier.

Vending Machine Packages—Br. 1,-119,243 and Br. 1,119,244 (Micro-therm Ltd.) Food packages for use in vending machines employing microwave heating systems.

Display Package—Br. 1,120,826 (W.E. Young) Blister type display package for meat, cheese and the like.

Bag Construction—Br. 1,121,752 (H. Sasai) Bag-like container for perishable foodstuffs made of net and carried by a collapsible frame.

Shrink-wrap Packaging—Br. 1,121,-769 (Dynamit Nobel AG) Cheese is shrink-wrapped in a biaxially-stretched film of an amorphous polyamide made by the condensation of terephthalic acid or its methyl ester with a hexamethylene diamine.

Inhibition of Oxidation—Ger. 1,269,-874 (Olin Mathieson Chemical Corp.) Transparent packaging films are coated with mixtures of propyl gallate, butylated hydroxytoluene and citric acid to retard oxidation.

Banana Packaging—Ger. 1,273,408 (Diamond Intern. Corp.) Bananas are packaged on a crescent shaped molded tray and wrapped with conventional heat shrinkable film. •

professional placement

SITUATIONS WANTED

Reply directly to advertiser BY BOX NUMBER (where indicated) via: Business Manager, Institute of Food Technologists, 221 N. LaSalle Street, Chicago, Illinois 60601.

Senior Food Technologist-Flavorist, 46, with 12 years of successful product development, Q.C. and production experience in the Flavor and Fruit products industry seeks challenging opportunity with progressive company. Am familar with bakery, confections, ice cream and beverage industries and products. Multilingual interested in marketing and development. Will consider foreign assignment and/or partnership. Salary approx. $14,500. Please reply BOX 789.

Individual desires position with food processing and/or pharmaceutical companies in product quality control, product development and research or plant sanitation. Advanced study plus many years of work experience as Industrial Microbiologist, Food Chemist, and Quality Control Supervisor with leading manufacturers of food commodities. Salary—open. Please reply BOX 769.

FOOD TECHNOLOGIST—seeks challenging position in product development and research or quality control. 20 years experience in Quality Control and Plant Sanitation with most Canned and Frozen Fruits and Vegetables, jams and jellies, citrus juices and mushrooms. Wish to relocate in the Boston or Northeast Areas. Salary open. Please reply BOX 797.

Research Food or Dairy Technologist. Ph.D. 1/1969, 9 years experience in fermentation and in research and development. Location open. Salary negotiable. Please reply BOX 804.

Technologist desires position in developing frozen Oriental foods. Please reply BOX 799.

M.S. Quality Control Manager desires position on West Coast. Experienced in Basic and Applied Research, Product Development, and Quality Control. Also experienced with Bakery, Dairy, Grain Mill Products, Edible Oils, Poultry and Eggs. Salary, $12,000. BOX B-807.

M.S. Experience in Basic or Applied Research, Packaging, Product Development, Quality Control, and Sanitation desires Research and Development position in the Northern States. Salary, $8-10,000. BOX B-814.

M.S. Product Development position wanted. Experienced in Basic and Applied Research, Product Development, and Teaching. No location preference. Salary, $11,000. BOX B-818.

Chemist, experienced in freeze drying of coffee and fruit juices. Please reply BOX 800.

B.S. Experience in Production and Quality Control desires position as Quality Control Director. Product experience includes Dairy Products, Fruits and Vegetables, and Meat Products. Location open. Salary, $15–18,000. BOX A-607.

Ph.D. Research Management position wanted. Experienced in Basic and Applied Research and Research Management. Has worked with Bakery, Beverage, Meat Products, and Fruits and Vegetables. Eastern U.S.A. location preferred. Salary, $22–25,000. BOX C-802.

Ph.D. Food Technologist desires position in any location. Experienced in Basic and Applied Research, Product Development, Production, Quality Control, Sanitation and Teaching. Has also worked with Dairy Products, Meat Products, Poultry, Eggs, and Seafoods. Salary, $11,500. BOX C-810.

Ph.D. Research and Development or Quality Control position sought by man with experience in Basic and Applied Research, Product Development and Quality Control. Also, has worked with Dairy Products, Fruits, Vegetables, Grain Mill Products, Meat Products, Edible Oils, Poultry, Eggs, Seafoods, Sugar, Cane, and Beets. BOX C-813.

Food Technologist
Responsible management position desired by well-qualified individual with wide experience in the food and beverage industries. Prefer Eastern location. Salary open. Please reply BOX 803.

Ph.D. Experience in Basic and Applied Research seeks position in same. Also, has experience with Dairy Products and Seafoods. Salary, $12,500. BOX C-839.

Ph.D. Nine years' experience in Basic and Applied Research and five years' experience in Teaching would like position in Research and/or Teaching. Product experience includes Meat Products, Edible Oils, Poultry and Eggs. Salary open. BOX C-844.

Ph.D. Experience in Basic and Applied Research, Product Development, Production, Quality Control, Research Management, Sanitation, and Teaching seeks position in Research Development or Teaching. Has worked with Beverage, Dairy, and Grain Mill Products. Preferred location in Canada or outside U.S.A. Salary, $11–20,000. BOX C-854.

Ph.D. Nineteen years' experience in Basic and Applied Research and Teaching, and four years' experience in Research Management desires Teaching and Research position. Also has had experience with Meat Products and Edible Oils. Salary, $10,000. BOX C-861.

POSITIONS AVAILABLE

Reply directly to advertiser BY BOX NUMBER (where indicated), including the company name of your current employer, via: Business Manager, Institute of Food Technologists, 221 N. LaSalle Street, Chicago, Illinois 60601.

Food Openings—Nationwide. All fees company paid. Food Technologists, $9-16,000; Microbiologists, to $15,000; Process Engineers, to $16,200; Analytical Chemists, to $14,500; Packaging Specialists, to $16,000; Project Engineers, to $16,000; Home Economists, to $9,000; Production Supervisor Trainees, to $8,500; Quality Control Manager (Bakery Prod.), to $11,000; Section Head, Confectionery Prod., to $14,000; Dairy Technologist, to $12,000; Process Supervisor (Poultry), to $9,600; Senior Devel. Scientist (Gourmet & Convenience Items), to $15,000. Only a partial listing—many other openings. Contact in confidence: Philip M. Anderson. Longberry Employment Service, Inc.; Suite 607 Niles Bank Bldg.; Niles, Ohio 44446; (216) 652-5871.

CHEMISTS
FOOD TECHNOLOGISTS

We have need for recent graduates as well as food chemists with appropriate experience for research positions in our expanding product development group. This is an excellent opportunity with a sound and progressive company located in the Princeton, N.J. area. Generous company benefits including education assistance.

Send confidential resume including salary history and requirements to Personnel Manager, FRENCHETTE Division of Carter-Wallace, Inc. Cranbury, N.J. 08512

An Equal Opportunity Employer

Leading citrus products manufacturer in Florida seeks Research and Development Food Technologist. Requires applicant who has degree in Food Technology or equivalent desiring position to exercise creative ability. Please reply BOX 806.

Food Technologist, Midwest location. Degree in food technology required with experience preferred for individual in Quality Control. Products include jam, jellies, dried fruit for pie mixes. Salary, $12,000. BOX X-867.

Food Scientist, Western location. Individual with M.S. or Ph.D. with some laboratory experience needed for position in basic research. Products include emulsifiers, gels, films, and fibers. BOX Y-810.

professional placement

CHEF
FOOD TECHNOLOGIST

East or Midwest location for the qualified specialist interested in the creation and development of products for our expanding seasoning and ingredient operations. Must enjoy working with our sales representatives and customers on their specific requirements. Unlimited potential and opportunity because of our contact with all aspects of the food industry.

Send resume covering experience, education and salary to:

Albert D. Henderson
Griffith Laboratories
1415 W. 37th Street
Chicago, Illinois 60609

Research Technologist, Midwest location. Individual with degree in food science for position in product development. Experience not necessary. Salary, $7-7,800. BOX X-702.

RESEARCH
SCIENTIST

Scientist with a B.S. degree minimum capable of carrying out studies in flavor transfer, application of flavor to cigarets and improve practical methods of flavor application to tobacco. Applicant must be able to bridge gap between subjective and objective and research and product development. Five years experience in organic or possibly physical chemistry or mechanical engineering desirable. Excellent working conditions, company paid benefits including profit sharing and relocation expenses. Write to:

Manager of Administration
PHILIP MORRIS RESEARCH CENTER
P.O. BOX 3-D
Richmond, Va. 23206

An Equal Opportunity Employer.

FOOD TECHNOLOGIST

This is an outstanding opportunity to work with R & D section of a national food company on a wide variety of products.

If you are eager to assume responsibility and can use imagination in the development of new products you will enjoy this challenging work. Degree in Food Technology or Chemistry with one to four years experience is necessary.

We are an expanding national company headquartered in the midwest, and are most anxious to attract people who want to build with us. We can offer you unusual opportunities to advance.

Excellent starting salary and benefit program.

Send résumé to:

PERSONNEL DIRECTOR
CONTINENTAL COFFEE COMPANY
2550 N. Clybourn Avenue
Chicago, Illinois 60614

PRODUCT DEVELOPMENT SECTION HEAD

Major expansion of our Research & Development Lab has created an opportunity to head up a new Product Development Section. This individual must possess a broad knowledge of Food Science and have the ability to stimulate *creative development* on frozen, packaged and canned products for retail and institutional markets.

We are a diversified growth company and have enjoyed rapid expansion in recent years. This position provides an excellent opportunity for individual growth and professional development. Minimum of 5 years' experience in the development of related products. B.S. in Food Science or related field. Advanced degree desirable.

Please address all inquiries; including education, personal data, experience and salary requirements, in confidence to: *Director of Research and Quality Control, American Home Foods, Milton, Pennsylvania.*

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FOOD TECHNOLOGIST

Significant Company growth and expanding technology requires an addition to our Quality Assurance Department. We are a multi-plant organization specializing in high quality luncheon meats and meat specialities. The position of Food Technologist is available at each of our plant locations, located in: Fremont, Ohio; Chicago, Illinois; Kalamazoo, Michigan and Fort Wayne, Indiana.

The person in this position will be responsible for effectively maintaining the process capability necessary to assure the quality conformance of that particular plant's products by solving problems and developing and carrying out test programs and acting as technical consultant.

Required is a B.S. Degree in Food Technology and preferably some experience in the food industry.

This position offers adequate challenge and good opportunity for professional growth. Eckrich provides a comprehensive benefit package. Salary commensurate with education and experience. Send resume, including educational background, work experience and salary requirements to:

Corporate Industrial Relations Department
Peter Eckrich & Sons, Inc.
1025 Osage Street
Fort Wayne, Indiana 46808

AN EQUAL OPPORTUNITY EMPLOYER

MEATS TECHNOLOGIST

This position is in our Corporate Research and Development Department located in Fort Wayne, Indiana. This person will be responsible for conducting assigned projects of major importance within the field of meat technology as it relates to packing, supply and development of fabricated end products for consumer and institutional use.

This position requires a person with a Masters Degree with 3 to 5 years of appropriate experience or a Ph.D. Degree in Meat Science. A Bachelors Degree with particularly good experience will be given serious consideration.

This position offers adequate challenge and good opportunity for professional growth. Eckrich provides a comprehensive benefit package. Salary commensurate with education and experience. Send resume, including educational background, work experience and salary requirements to:

Corporate Industrial Relations Department
Peter Eckrich & Sons, Inc.
1025 Osage Street
Fort Wayne, Indiana 46808

AN EQUAL OPPORTUNITY EMPLOYER

Flavor Chemist, Eastern location. Minimum five years experience with B.S. degree in food technology required for work in flavor development. Salary, $8–10,000. BOX X-861.

Food Technologist, Southeastern location. New graduate with B.S. in food technology needed for product development position. Initial work in product concept and evaluation. BOX X-860.

ARE YOU READY TO MOVE?

PRODUCT DEVELOPMENT $20,000
Broad range of exp.; develop and improve products for retail, institutional and industrial use.

QUALITY CONTROL ASSISTANTS $10,000
Frozen dinners and allied. Travel divisional plants; counsel, inspect, etc.

RESEARCH & DEVELOPMENT....$13,000
Snack areas; dry extruded types, etc.; degree required.

PRODUCT DEVELOPMENT & IMPROVEMENT $12,000
For large manufacturer of broad range food ingredients.

MEAT TECHNOLOGISTS $14,000
Degree required; for product development, ingredient houses; technical service, for same and product development snack and classical areas.

PRODUCT DEVELOPMENT & IMPROVEMENT $13,000
Degree required. Mfr. institutional prdts.; jams & jellies, etc.

PACKAGING TECHNOLOGIST....$12,000
Degree necessary. Mfr. of industrial and consumer products.

We have other requirements for degreed Food Technologists.

Client companies pay all fees, relocation and interview expenses. For full details, contact in confidence:

WALTER FIERS
Food Division
DRAKE ASSOCIATES, INC.
29 E. Madison Bldg., Chicago, Ill. 60602
(312) Financial 6-8700

RESEARCH BIOCHEMIST

This position is in our Corporate Research and Development Department located in Fort Wayne, Indiana. The incumbent will develop plans of attack and carry out projects of major importance in bio-chemistry. Initial work is on meat proteins. A B.Sc in Biochemistry or Chemistry and either graduate training or experience in protein chemistry is required.

This position offers adequate challenge and good opportunity for professional growth. Eckrich provides a comprehensive benefit package. Salary commensurate with education and experience. Send resume, including educational background, work experience and salary requirements to:

Corporate Indutrial Relations Department
Peter Eckrich & Sons, Inc.
1025 Osage Street
Fort Wayne, Indiana 46808
AN EQUAL OPPORTUNTY EMPLOYER

An internationally known manufacturer of flavors and perfumes is seeking the services of a qualified individual for general management responsibilities in Canada. Candidates should have a minimum of five years of successful experience in the essential oil field. This represents a real growth opportunity. Please reply to BOX 802.

FOOD TECHNOLOGIST

Midwest: Large Independent meat processor requires manager with Bachelor of Science degree willing to contribute to a growing organization. Help to expand program pertaining to product composition, food additives, and related compounds. Individual must have initiative and foresight for food product development. Excellent opportunity, good salary, and fringe benefits. Send complete resume in confidence to BOX 786.

Technical Service Representative, Midwest location. Young individual with B.S. in Science required for formulating mixes for baking industry, modifying existing mixes, and servicing clients. Salary $8–10,000. BOX X-869.

Flavor Chemist, Eastern location. Minimum 5 years experience in flavor research and B.S. in chemistry needed for developing original flavors. Salary, $12–13,000. Box X-629.

SENIOR FLAVOR CHEMIST

N.Y.City Location

We are a major producer of flavoring materials. Our expanding Flavor Division is in need of a highly Creative Flavor Chemist to work in the food products area. Emphasis will be in soft drink flavoring.

B.S. in Chemistry or Pharmacy is preferred plus 7 to 10 years of flavor experience.

Reply in confidence to:

Personnel Manager
Givaudan Corporation
321 West 44 Street
New York, N.Y. 10036
AN EQUAL OPPORTUNITY EMPLOYER

FOOD CHEMIST

Product Development

An unusual opportunity to join the R & D Department of the nation's leading food company. Duties include bench-top work to develop new food products and improve present product lines. A variety of challenging projects will present ample opportunity to demonstrate ability and potential. 3 to 5 years of product development experience plus degree in food technology, dairy technology, chemistry or related fields.

This job offers a bright future for the right man as well as excellent starting salarly and outstanding benefits.

Send inquiry to Mr. John O'Connor:

GENERAL FOODS CORPORATION
7400 S. Rockwell
Chicago, Illinois 60629
or call (312) 925-1200

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PLANT MANAGER $21,000
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CHEMIST $16,000
New product dev. Foods
CHEMICAL ENGINEER ..$14,000
Snack foods. Processing
PRODUCT MANAGER $17,000
Foods & beverages. M.E.—I.E.
BIOCHEMIST $16,500
Food bacteriology

Client companies pay all fees and expenses incidental to hiring. For full details in complete confidence, send resume to:

F L G KUNZ
Manager-Food Industry Division
CADILLAC ASSOCIATES, INC.
29 E. Madison Bldg.
Chicago, Ill. 60602
(312) Financial 6-9400

SALES OPPORTUNITY

Excellent sales opportunities throughout U.S. and Canada for men with experience in the Dairy or Food Industry. Formal education in this field will be a definite asset. Draw and commission, expenses paid, car furnished, full participation in employee benefit program. Send résumé to:

Specialty Products Department
J. B. Ford Division
Wyandotte Chemicals Corporation
Wyandotte, Michigan 48192

Italian MD, Food Technologist, 41, with long experience as consultant to Italian food and dietetic companies, offers his services as market consultant in Italy to US companies engaged in similar business interested in the Italian market. Please reply BOX 794.

FOOD TECHNOLOGY— FOOD ENGINEER

Qualified man needed for position of assistant director of manufacturing. Person should have two to five years food engineering or food processing experience. He should be familiar with most common food processing equipment especially dryers, blenders, and conveyors.
This is a growth position with full, fringe benefits and salary based on experience and background.
Please send resume in confidence to:
Dr. Fred Barrett
Food Industries Corporation
P. O. Box 20479
Dallas, Texas 75220
A/C 214 357-9451

PROFESSIONAL PLACEMENT SPECIALISTS SERVING FOOD INDUSTRY PERSONNEL

Confidential resumes (or letter) to R. C. Myers. We will respond to your inquiry within three days. Our clients pay all fees & expenses. (215) LO 1-6300.

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FOOD TECHNOLOGY

Official Publication of the

Institute of Food Technologists

The Professional Society of Food Technologists

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VOLUME 22

JANUARY-DECEMBER, 1968

Institute of Food Technologists

The Institute of Food Technologists is a professional society of scientists, engineers, educators and executives in the field of food technology. Food technologists are professionals who apply science and engineering to the research, production, processing, packaging, distribution, preparation and utilization of foods. Individuals who are qualified by education, special training, or experience, are extended an invitation to join in professional association with the select group of the food industry's scientific and technological personnel who are Institute members. Membership is worth many times its modest cost, reflecting positive benefits, stimulation and opportunities for the individual and his business or profession.

OBJECTIVES

The Institute, as a non-profit, professional, educational society, has several major aims: to stimulate investigations into technological food problems; to present, discuss and publish the results of such investigations; to raise the educational standards of Food Technologists; and to promote recognition of the scientific approach to food and the basic role of the Food Technologist in industry. All of these activities have the ultimate objective of providing better and adequate foods for mankind.

ORGANIZATION AND PROGRESS

Organized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 9,500 (1968). It is world-wide in scope, with members in the Americas, Scandinavia, England, Holland, Germany, France, India, Australia, New Zealand, and Japan, among others.

QUALIFICATIONS FOR MEMBERSHIP

Professional Members. Any ethically qualified person who has had training and experience in food technology, or who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for such membership is, in general, graduation from a college, university or similar institution in which he has majored in one or more of the sciences or branches associated with food technology. The minimum experience shall be three years experience in food technology.

Members. Any ethically qualified person active in special or limited aspects of food technology, who is an Administrator, Director or Executive under whose jurisdiction operations in food technology are conducted; or those engaged in the dissemination of knowledge of food technology; or one whose work requires a general knowledge of the broad principles of food technology as it applies to the products, processes or equipment with which he or she is concerned; or a recent graduate in food technology, or applicable branches of science and engineering who has entered a career in food technology; shall be eligible to become a Member.

Student Members. Any ethically qualified person who is registered as a full-time student in an educational institution with at least Junior (third year) standing, who is a candidate for a Bachelor's or higher degree in one or more of the sciences or branches of engineering associated with food technology, shall be eligible for membership as a Student Member. That classification shall be his status only until the end of the calendar year in which he completes his schooling.

DUES

Professional Members and Members—$20.00 a year; Students—$2.50. Includes subscription to Food Technology, Annual Directory (and Journal of Food Science if requested).

PUBLICATIONS

The Institute publishes two journals. Food Technology, issued monthly, is the official journal of the Institute. Besides covering many fields of interest to food technologists throughout the world, it publishes the results of research in food technology and their practical application to industry. The Journal of Food Science, issued bimonthly, is devoted exclusively to papers presenting original investigations and basic research in fundamental food components and processes. In addition, an IFT WORLD Directory & Guide is published annually.

REGIONAL SECTIONS

Where 25 or more members live within commuting distance of a given point, a regional section may be established. Meetings can be held at more frequent intervals by such groups. Presently, there are 40 regional sections.

AFFILIATE ORGANIZATIONS

Affiliate certificates may be granted to food technology organizations outside the U.S.A. There are currently five chartered affiliate organizations.

ANNUAL MEETINGS

An Annual Meeting of the Institute provides a specially-organized technical program, awards banquet, and industrial exhibit of equipment, services, processes and ingredients. The program is designed to emphasize current trends and technological developments. Special guest speakers are invited.

AWARDS

The Institute administers the following awards:

NICHOLAS APPERT AWARD. Purpose of this award (Medal furnished by the Chicago Section, and $1,000) is to honor a person for pre-eminence in and contributions to Food Technology.

BABCOCK-HART AWARD. Purpose of this award ($1,000 and Plaque sponsored by The Nutrition Foundation) is to honor a person for contributions to Food Technology that have improved public health through some aspects of nutrition or more nutritious food.

IFT INTERNATIONAL AWARD. Purpose of this award (Silver Salver sponsored by Australian Institute of Food Science and Technology, and $1,000) is to recognize an IFT Member for promoting international exchange of ideas in Food Technology.

FOOD TECHNOLOGY INDUSTRIAL ACHIEVEMENT AWARD. Purpose of this award (Plaques to company and individuals) is to recognize and honor the developers of an outstanding new food process and/or product representing a significant advance in the application of Food Technology to food production, successfully applied in actual commercial operation.

IFT AWARD FOR RESEARCH. Purpose of this award ($1,000 and Plaque) is to recognize a research scientist 35 years of age or younger, who has demonstrated outstanding ability in Food Science or Technology research.

FELLOWSHIPS

- Florasynth—$1,000 and plaque
- General Foods—Three, each $4,000 and plaque
- IFF—$1,000 and plaque
- Monsanto—$1,000 and plaque
- Nestlé—Two, each $1,000 and plaque
- Pillsbury—Two, each $1,000 and plaque
- Samuel Cate Prescott—(donors: various industrial firms)—$1,000 and plaque

Purpose of IFT-administered Fellowships is to encourage graduate work in the field of Food Science and Technology directed to extending or improving knowledge in some phase of food conservation, food production, or food processing. Available to graduate students.

SCHOLARSHIPS

- R. T. French (donor: R. T. French Co.)—Two, each $1,000; accompanied by plaque
- Fritzsche's F. H. Leonhardt Sr. Memorial (donor: Fritzsche Brothers, Inc.)—$1,000 and plaque
- Gerber (donor: Gerber Products Co.)—Six, each $1,000; accompanied by plaque.
- Alexander E. Katz Memorial (donor: F. Ritter & Co.)—$1,000 and plaque
- Mexico (donor: Mexico Section of IFT)—$1,000 and plaque

Purpose of IFT-administered Scholarships is to focus attention on the need for more young people in Food Science and Technology, and to encourage deserving and outstanding students to take undergraduate work leading to a Bachelor's Degree in Food Science, Food Engineering, or Food Technology. Available to incoming Juniors and Seniors who have completed at least one term of study at the institution from which they expect to earn a baccalaureate degree.

IFT SCHOLARSHIPS

- IFT Freshman/Sophomore Scholarships—Thirty, each valued at $500 and including a complimentary subscription to Food Technology during the tenure of the scholarship.

Purpose of the IFT Scholarships is to attract and encourage worthy students to enter the fields of Food Technology, Food Engineering or Food Science. Available to incoming college freshmen, and sophomores.

Author Index — *Food Technology* — Volume 22, 1968

Erratum Notice

The legends for Figures 1 and 2 on page 1029 of Volume 22 should be *INTERCHANGED* (they appear in the article "Concentration of Soymilk" by Winston Yau-Lai Lo, K. H. Steinkraus and D. B. Hand). Thus the legend for Figure 1 should read: "Viscosity measurements of a 20% solids soymilk at various time intervals" and the legend for Figure 2 should read: "Apparent viscosity of soymilk at various % solids content."

Subject Index — *Food Technology* — Volume 22, 1968

Book Review Index

Food Technology — Volume 22, 1968

COMING EVENTS

Meetings and Conferences

JANUARY

20–22—Dairy Conference. Univ. of Georgia, Athens, Ga. Prof. Morrison Loewenstein, Dairy-Science Dept., Univ. of Georgia, Athens, Ga. 30601.

21–24—Am. Soc. of Agronomy Symp. on Physiology of Crop Yields. Univ. of Nebraska, Lincoln. K. E. Clark, Am. Soc. of Agronomy, 677 S. Segoe Rd., Madison, Wis. 53711.

22–24—Instrumentation Symposium for the process industries. College Station, Texas. Dept. of Chem. Engg., Texas A&M Univ., College Station, Texas 77843.

27–30—Am. Soc. of Heating, Refrigerating & Air Conditioning. Conrad Hilton, Chicago. Julia I. Szabo, ASHRAE Hq., 345 E. 47th St., New York City 10017.

FEBRUARY

2–7—Am. Soc. for Testing & Materials, winter mtg. Denver Hilton, Denver, Colo. T. A. Marshall Jr., ASTM Hq., 1916 Race St., Philadelphia, Pa 19103.

4–7—24th Ann. Technical & Management Conference, Reinforced Plastics/Composites Div., Soc. of Plastics Ind. Shoreham Hotel, Washington, D. C. Frederick C. Schierbaum, The Society of the Plastics Industry, Inc., 250 Park Ave., New York City 10017.

6—3rd Ann Symp., Commercial Applications of Ultrasonics. Intern. Hotel, J.F.K. Intern. Airport, New York City. Ultrasonic Manufacturers Assn., 271 North Ave., New Rochelle, N. Y. 10801.

9–12—Food Update Seminar. Sheraton-Boston Hotel, Boston, Mass. Food & Drug Law Institute, Inc., 205 E. 42nd St., New York City 10017.

12—Symposium on Nutrition and Food Technology. Lake Shore Club, Chicago. Sponsored by Ill. State Medical Soc., Chicago Nutrition Assn. and Chicago Section of IFT. Ill. State Medical Soc., 360 N. Michigan Ave., Chicago, Ill. 60601.

12–14—Ann. Technical Meeting, Mayonnaise & Salad Dressings Inst. Ambassador Hotel, Chicago. Mayonnaise & Salad Dressing Inst., 25 E. Chestnut St., Chicago, Ill. 60611.

13–16—Poultry & Egg Fact Finding Conference. Municipal Auditorium, Kansas City, Mo. Harold M. Williams, Institute of Am. Poultry Industries, 67 E. Madison St., Chicago, Ill. 60603.

24–25—Semi-Ann. Mtg., Nat. Live Stock & Meat Board. Phoenix, Ariz. Meat Board News Service, 36 S. Wabash Ave., Chicago, Ill. 60603.

25–26—Natl. Dairy Engineering Conference. Kellogg Center, Michigan State Univ. D. R. Heldman, Dept. Agricultural Engineering, Michigan State Univ., East Lansing, Mich. 48823.

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• To be considered for listing in EARLIEST issue possible—which is APRIL 1969—submit "Coming Event" information by Feb. 20.

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1970	San Francisco	May 24-29
1971	New York	May 23-28
1972	Minneapolis	May 21-25

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